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FIELD STUDIES OF BEACH CONES AS COASTAL EROSION CONTROL/REVERSAL DEVICES FOR AREAS WITH SIGNIFICANT OIL AND GAS ACTIVITIES

Final Report

CONTRACT DE-AC22-92MT920002

Chemical Engineering Department
Tulane University

September 18, 1995

Contract Date: February 24, 1992

Anticipated Completion Date: February 23, 1995

Government Award: $ 268,999.00

Program Manager: Dr. Victor J. Law

Principal Investigator: Dr. Victor J. Law

Technical Project Officer (COR): Dr. Brent W. Smith

Reporting Period: February 24, 1992 - September 18, 1995

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Abstract

The primary objective of this project was to evaluate the utility of a device called the "beach cone" in combating coastal erosion. Seven initial sites were selected for testing beach cones in a variety of geometric configurations. Permits were obtained from the State of Louisiana and the U. S. Army Corps of Engineers to perform the work associated with this study. Six hundred beach cones were actually installed at six of the sites in late July and early August, 1992. One of the initial sites was abandoned because it was found to be unsuitable for beach cone placement. In addition to these six sites, and additional 180 cones were installed at an eighth site in December of 1992. Findings indicate that beach cones accreted significant amounts of materials along the beach of a barrier island, and they might have been instrumental in repairing an approximately 200 meter gap in the island. At the eighth installation the amount of accreted material was measured by surveys to be 2200 cubic meters (2900 cubic yards) in February of 1993, when the cones were found to have been completely covered by the material. At other test sites, accretion rates have been less dramatic but importantly, no significant additional erosion has occurred, which is a positive result. The cost of sediment accretion using beach cones was found to be about $13.72 per cubic yard, which would be much lower if the cones were mass produced (on the order of $3.00 per cubic yard). The survival of the cones through the fringes of Hurricane Andrew indicates that they can be anchored sufficiently to survive significant storms. The measurements of the cones settling rates indicate that this effect is not significant enough to hinder their effectiveness. It is too soon to state the categorical success of the beach cones, but results to date are encouraging.

A subcontract to Xavier University to assess the ecological quality of the experimental sites involved the study of the biogeochemical cycle of trace metals. The highest concentration of heavy metals (arsenic, cadmium, copper, lead, selenium and zinc) were near a fishing camp while the lowest levels were in the beach sand of a barrier island. This suggests that the metals do not occur naturally in these areas, but have been placed in the sediments by man's activities.

A subcontract to Louisiana State University concentrated on historical sedimentation rates at the experimental sites and the accretion rates after beach cone placement. While accretion at some sites was substantial, it was not sufficient to support new marsh biota.

Executive Summary

Beach cones are hollow truncated conical structures made of lightweight concrete with a larger diameter of about 1 m and a smaller diameter of about 0.6 m and a thickness of about 3 cm. Each cone weighs approximately 40 kg. Beach cones are typically deployed in a pyramid of two or three layers with a typical arrangement of two rows of six cones on the bottom and a single row of five cones on the top layer. Pairs of cones are connected by an interstitial "wave block" which is molded of the same concrete material to fit the contours of the cones. Each wave block weighs about 35 kg and has a two inch vertical hole through it so that PVC pipe can be driven through the wave block and into the underlying media. The geometry of a pyramid of cones is such that layers of wave blocks align so that the PVC pipe stabilizes the entire structure.

The main objective of the present study is to deploy 600 beach cones and associated wave blocks in areas where coastal erosion has been a serious problem and to assess the utility of these devices in combating the problem of coastal erosion. Seven potential sites were selected and cones were installed at six of these sites; one site was abandoned since its shoreline had no slope at all, which was found to be a requirement for effective beach cone installation. The six experimental sites included an eroded marsh area between two bays, the shoreline of a bayou, the shoreline of a bay, the entrance to a pipeline canal, a second eroded marsh between two bays (the second of these was an area where more sediment was thought to be available than for the first one), and an eroded shoreline of a barrier island. All cones were deployed in late July and early August, 1992.

A secondary study was begun in December of 1992 with the installation of 180 beach cones at Fourchon beach in south Louisiana. This study was funded by the Louisiana Department of Natural Resources. The most important difference in the sites was that the accessibility of Fourchon beach allowed the direct measurement of accretion amounts by detailed topological surveys.

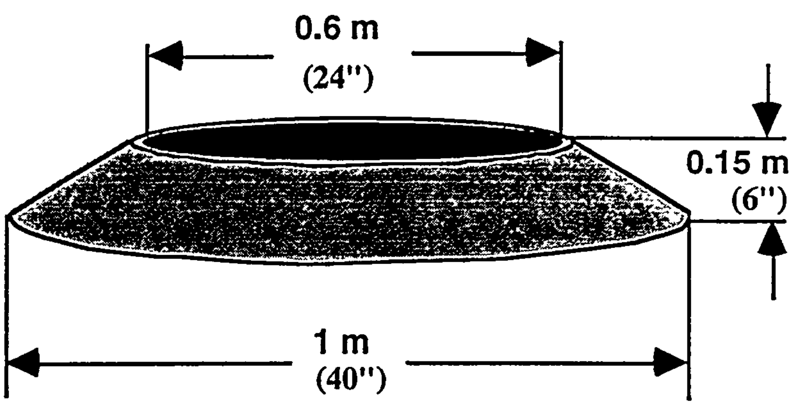
The test sites have been observed every two to four weeks since their placement, and findings indicate that beach cones accreted significant amounts of materials along the beach of the barrier island site, and they might have been instrumental in repairing an approximately 200 meter gap in the island. The accretion at Fourchon beach was measured in February to be about 2200 cubic meters (2900 cubic yards). At other test sites, accretion rates have been less dramatic but importantly, no significant additional erosion has occurred. It is too soon to state the categorical success of the beach cones, but results to date are encouraging.

Heavy metal concentrations in sediments at selected sites were studied through a subcontract to Xavier Univerity. Their results indicate that high metal concentrations are due primarily to anthropogenic activity and not to natural processes.

Historical sedimentation (subsidence) rates and accretion rates after beach cone placement were studied through a subcontract to Louisiana State University. They found that while accretion at some sites was substantial, it was not sufficient to support new marsh biota.

Introduction

Coastal Louisiana has become the focus of an intense national debate concerning the control of coastal erosion. Although there are many causes of erosion in this area, the rate of beach and marsh retrogradation has been accelerated by man's activities. The goals of the current project are to test and evaluate the effectiveness of a particular device call the "beach cone" with regard to arresting erosion and possibly reversing the process by accreting sediments. Beach cones were invented by William J. Mouton, Robert Grush, and Dolores B. Alton as indicated in U. S. Patent Number 4,988,844, March 12, 1991. A description of a beach cone appears in Figure 1.



Weight: 40 kg (88 lb) Weight in water: 20 kg (44 lb)
Material of construction: lightweight concrete

Figure 1. Beach Cone

Most often, beach cones are deployed in pyramids of two or three layers. An example of such a configuration is shown in Figure 2. In that figure, the pyramid is three-high with the bottom layer consisting of fifteen cones with interstitial "wave blocks" that interlock adjacent cones. The second layer has eight cones and the top layer consists of three cones and two wave blocks, so the entire pyramid contains twenty six cones. Although not shown in the figure, each wave block is cast with a nominal two-inch vertical hole through which PVC pipe is driven. The geometry of the pyramid is such that the holes in the wave blocks align vertically so that the PVC pipe can be driven directly through the pyramid and into the sediment beneath. This gives the pyramid great stability but does not render it entirely rigid.

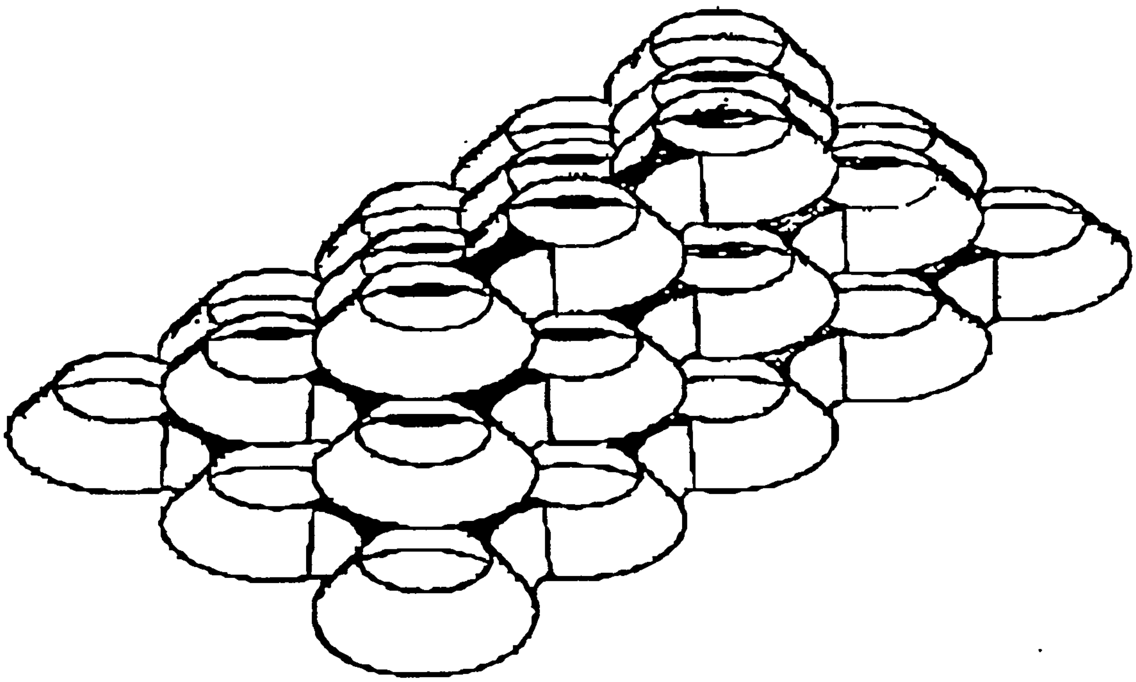


Figure 2. A 3-high pyramid of 26 cones with wave blocks.

Approximately 600 beach cones, with the associated wave blocks, have been installed at six locations within a typical barrier island/marsh ecosystem located south of Empire, LA in Plaquemines Parish. The map of Figure 3 identifies the approximate locations of the test sites. Note that there is no Site 5 since it was abandoned, having been judged not suitable for this study. The installed beach cones were monitored for a six month period. This report gives details about the installation process and the results of the monitoring though the end of February, 1993.

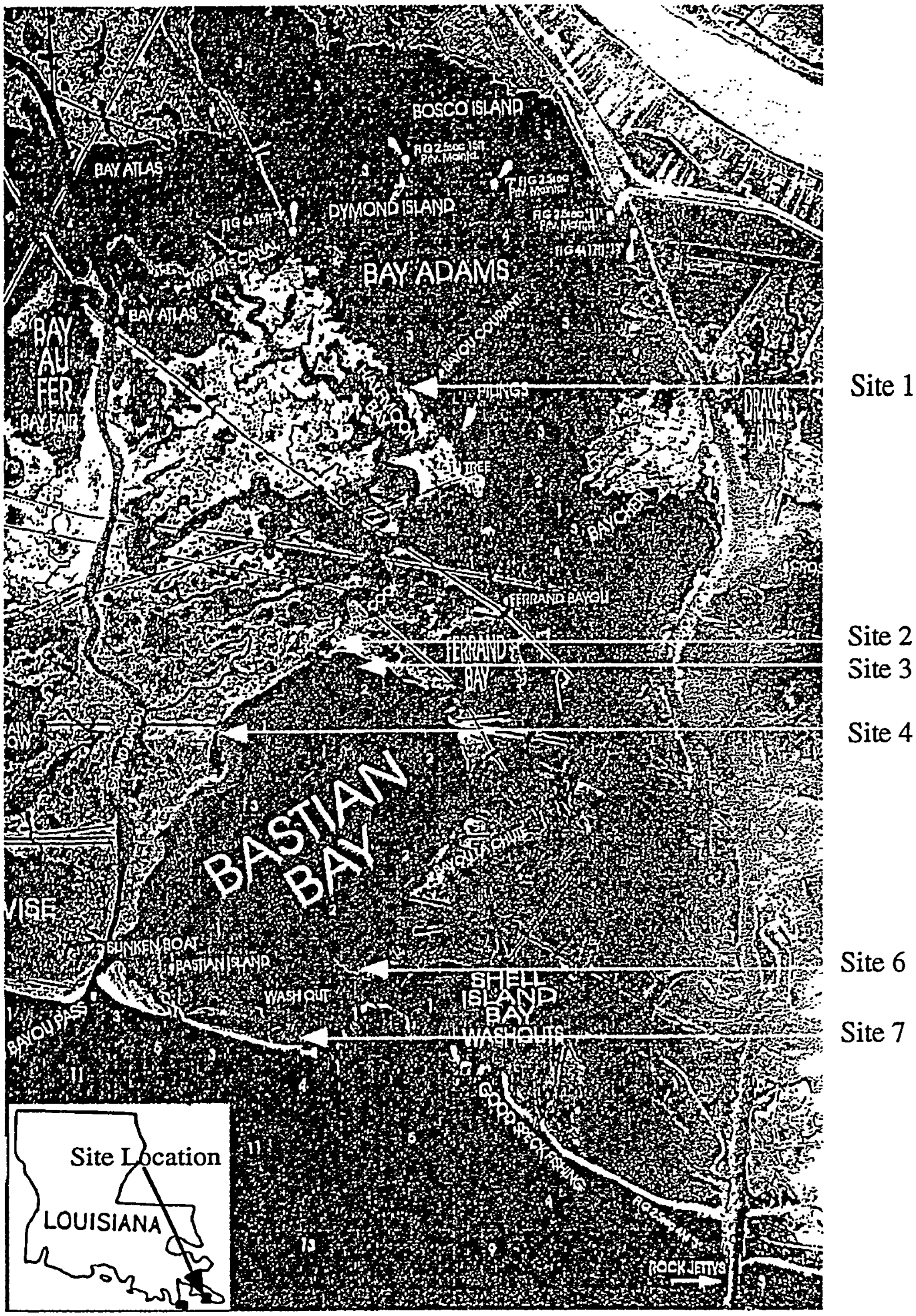


Figure 3: Map of the Empire to Shell Island estuary.

Project Description

The plan called for six months of preliminary work, sixteen months of actual study at the selected experimental sites and two months for preparation of the final report and for dismantling of the experimental sites (if necessary). A no-cost extension was granted for one additional year of observations. The primary objective of the study was to assess the viability of beach cones as a coastal erosion control/reversal device.

Task 1: Preliminary studies included the following sub-tasks:

Sub-Task 1.1: Planning and Site Selection

Involved the detailed planning and selection of specific experimental sites. These tasks were scheduled for the first six months of the project.

Sub-Task 1.2: Permits

Involved obtaining permits to install the beach cones at the selected sites. Permits from the U.S. Army Corps of Engineers and the State of Louisiana were obtained. A subcontractor, Environmental Professionals, Inc. will assisted with the obtaining of permits.

Sub -Task 1.3: Initial Ecological Survey

Performed by subcontracting groups from Xavier University and Louisiana State University. Purpose was to establish existing conditions of sediments and biota at the proposed experimental sites.

Sub-Task 1.4: Environmental Report

Involved the preparation of an Environmental Report as soon as possible after initiation of the contract.

Sub-Task 1.5: Beach Cone Installation

By the end of the first six month period, all 600 beach cones with their constituent wave blocks were in place at the chosen experimental sites. Several different geometric combinations of cone installations were used, including the placement of single cones along bay shorelines and the banks of bayous and marshy inlets.

Task 2: Monitoring of the Beach Cones:
After installation of the cones, they were observed on a frequent basis over a 28 month period. Physical measurements were supplemented with both photographic and video taped evidence of their progress toward shoreline stabilization and/or sediment accretion. As sediments accreted, they were sampled by the Xavier and LSU groups.

Task 3: Ecological Surveys included the following sub-tasks:

Sub-Task 3.1: Mapping of Beach Biota and Assessment of Physical-Chemical Conditions:

Involved reconnaissance mapping of beach biota and assessment of the beach/ shoreline substrate. Core samples were taken and analyzed. This sub-task was performed by subcontractors from the Louisiana State University Laboratory for Wetlands Soils and Sediments.

Sub-Task 3.2: Evaluation of Beach Biota Changes:

Involved the evaluation of beach biota changes under various field conditions that are associated with the presence or absence of beach cones. This sub-task was performed by subcontractors from Xavier University.

Task 4: Information System:
Numerical data involving elevation changes, biota alterations, and changes in sediment characteristics were maintained.

Task 5: Final Report:
At the conclusion of the 34 month study, this final report was prepared. There were no areas where it was believed harmful to leave the beach cones in place, so no beach cone removal was necessary.

Project Status

A detailed account of work performed toward achieving the present status of the project is given in Appendix 1. A synopsis of these efforts is as follows:

1. Between January 15 and February 11, 1992, permit documents were prepared and submitted to the Louisiana Department of Natural Resources (DNR). The permit to proceed was finally issued on June 9, 1992. Other permits granted were from the U. S. Army Corps of Engineers, State Land Office. The Department of Health and Hospitals issued a letter of no objection.

2. On April 13, 1992, the Management Plan was submitted to DOE.

3. By May 24, 1992, seven sites had been selected for beach cone placement.

4. On June 3, 1992, Mr. Noel Brodtmann of EPL, Inc. (a subcontractor) submitted an Oyster Assessment to the State of Louisiana.

5. Shipment of beach cones to the C. L. Dill Company docks in Empire, LA began on July 17, 1992. Dill was selected as the installation contractor.

6. Beach cone installation began on July 20and was completed on August 7, 1992.

7. Hurrican Andrew passed near the sites in late August, 1992. All sites held up well to this extreme weather event.

8. Sixty eight (68) reconnaisance trips were made to the sites and observation recorded between August 29, 1992 and February 11, 1995. Over this period of time, significant accretion occurred at Site 2 and a large land mass appeared at Site 7.

9. Overall, the beach cone experiment is considered highly successful. This technology should be seriously considered as a tool to retard and potentially reverse coastal erosion.

Site Description and Initial Topology Study One

For the first study, seven sites in and around the Bayou Cook area of South Louisiana were selected initially. These sites were chosen based on their varied topology, sediment size, and incident wave characteristics, and are indicated in Figure 3. Site 5 is not listed because it was abandoned due to its lack of a sloped shoreline which made cone placement very difficult. The dates of cone placement and configuration of cones at each site is given chronologically in Table 1. As shown in this table the cones were deployed over a two and one-half week period in late July and early August of 1992. All these sites were monitored for changes every two to four weeks as weather permitted. Lack of funds prevented taking instrument measurements of elevations at the six sites in study one. All changes recorded were based on comparisons of visual inspection of the sites with nearby areas without cones. All of the areas without cones showed continued erosion.

Table 1. Cone Placement Date and Configuration - Study One.

Date (1992)	Site #	# of cones	Configuration
July 20	1	38	2 - double high
July 21	7	38	2 - double high
July 24 July 25	2	133	7 - double high
July 28	2	30	single file around eroding marsh area
July 30	3	19	1 - double high
July 30	7	10	zig-zag between islands started
July 31	7	84	zig-zag completed
August 4	7	76	1 - triple high 2 - double high
August 5	6	38	2 - double high
August 6	4	20	single file
August 7	2	118	single file
	Total #	of cones	600

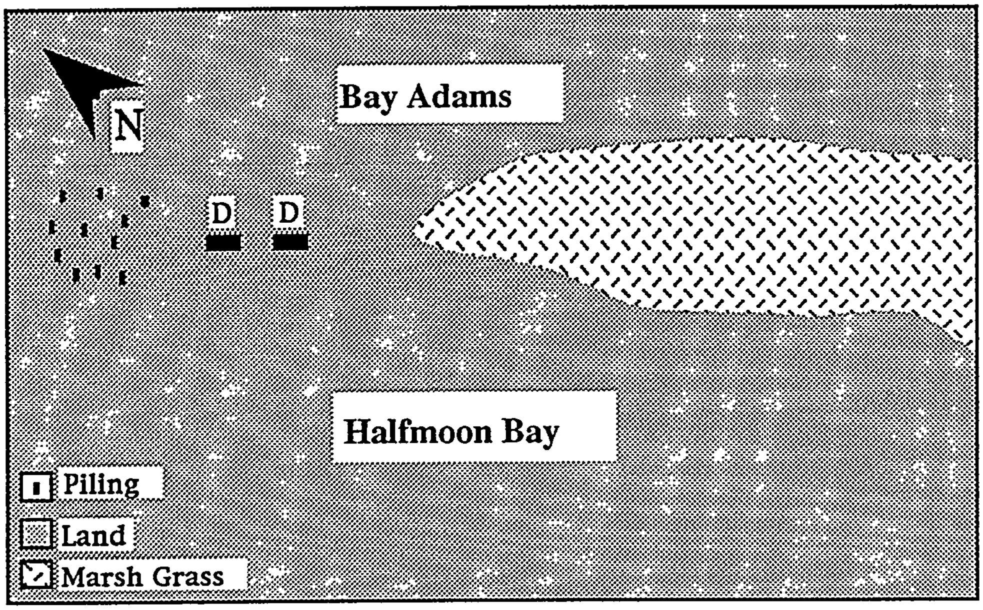


Figure 4. Site 1.

Site 1 is located at a pass between Halfmoon Bay and Bay Adams that has been widening due to erosion. This site was selected because it provided medium size sediment particles combined with waves of moderate to high energy caused by the long fetch distance available in Bay Adams. In addition, the site provided for competing waves from the Halfmoon Bay side. These waves were smaller due to the shorter fetch of Halfmoon Bay. At this site, two pyramids of nineteen cones each were placed directly on the eroding end of the pass between the remaining point of land and pilings, (see Figure 4), which mark the former extent of the land. The pyramids were placed end to end with about a twenty five foot (7.62 m) gap between them.

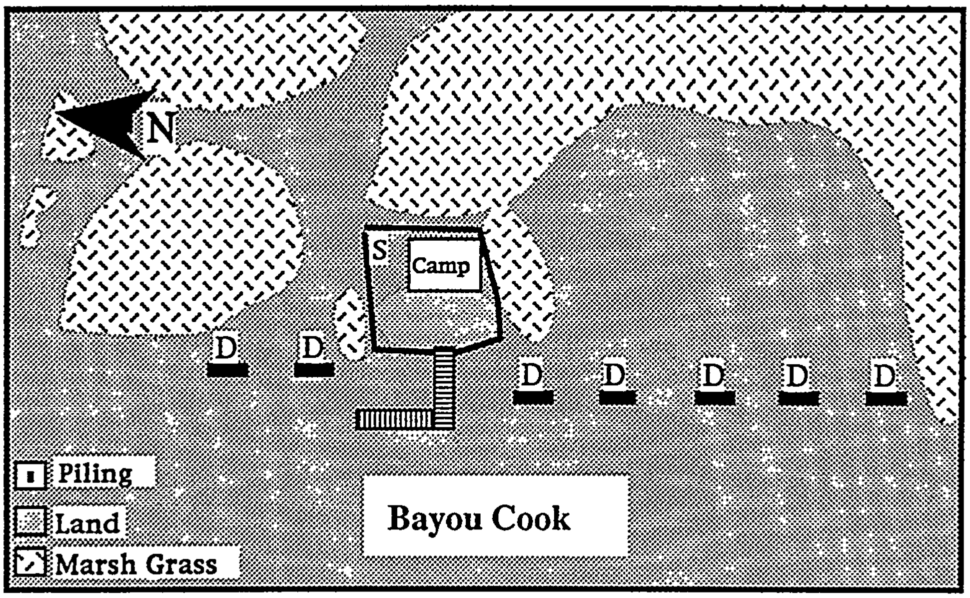


Figure 5. Site 2.

Site 2 was selected to determine the viability of using beach cones to reduce erosion along the shoreline of a bayou. The bayou runs from left to right along the bottom of Figure 5. This site, located at a point in Bayou Cook, is subject to waves caused by the short fetch across the bayou (approximately 600 ft., 183 m.), by an occasionally passing boat, and by strong tidal currents. The primary sediment at this site is small. Five sets of two high pyramids consisting of nineteen cones each were placed at the mouth of a lagoon which opens to the Bayou. Two sets of identical pyramids were placed at an opening in the marsh that has been receding rapidly over the past few years. Finally, a string of cones was laid single file around a camp to test the viability of cones forming a sediment trap.

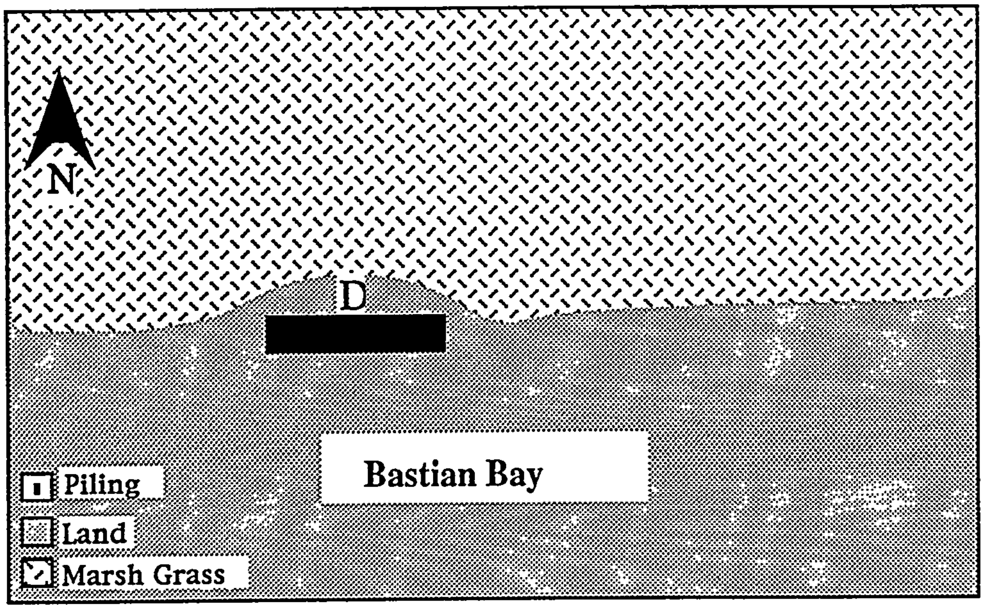


Figure 6. Site 3.

Site 3 is on the eastern shore of Bastian Bay several hundred yards from the opening of Bayou Cook. There is a small erosion zone at this site creating a dimple in the shore line, (see Figure 6). This site has the same sediment size as Site 2 but the wave energy is higher owing to the larger fetch distance in Bastian Bay. Due to the proximity to the Bayou Cook opening, there is a significant current along the shore during tidal changes. A single two high pyramid of nineteen cones was placed at this site parallel to the former shoreline.

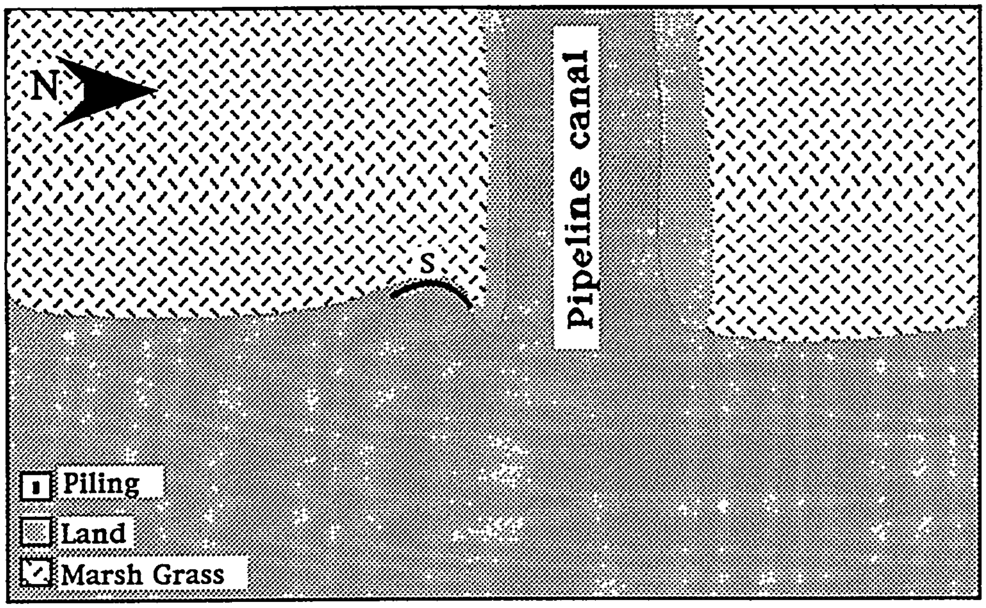


Figure 7. Site 4.

Site 4 is located at the opening of an oil/gas pipeline canal on the western side of Bastian Bay. It was selected to test the utility of using beach cones in a single file manner to repair small erosion damaged spots.

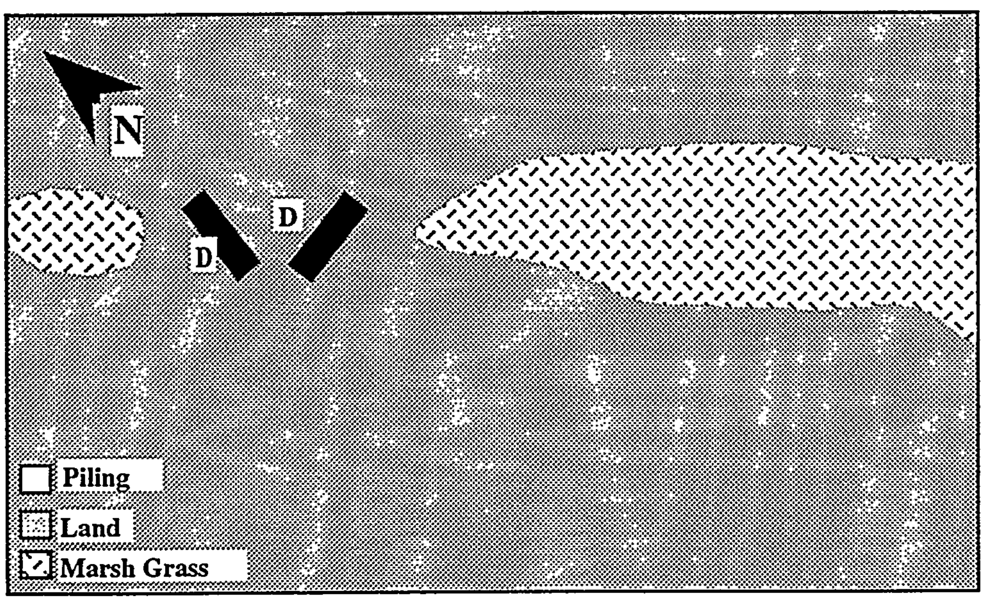


Figure 8. Site 6.

Site 6 is located on the north side of Shell Island Bay. It differs from Site 3 in two important ways. First, the location is far from the entrance to any canals or bayous which constrict the flow area available to the tidal waters and thereby increase the water velocity in the immediate area. Second, the sight is close to several "overwash fans" (sediment from a barrier island that has been washed into the back bays by large waves) resulting from the overtopping of Shell Island, by large waves. The overwash fans provide a larger sediment size, without requiring the placement of the cones in a high wave energy situation. Two pyramids consisting of nineteen cones each were place at this site in a V shaped pattern.

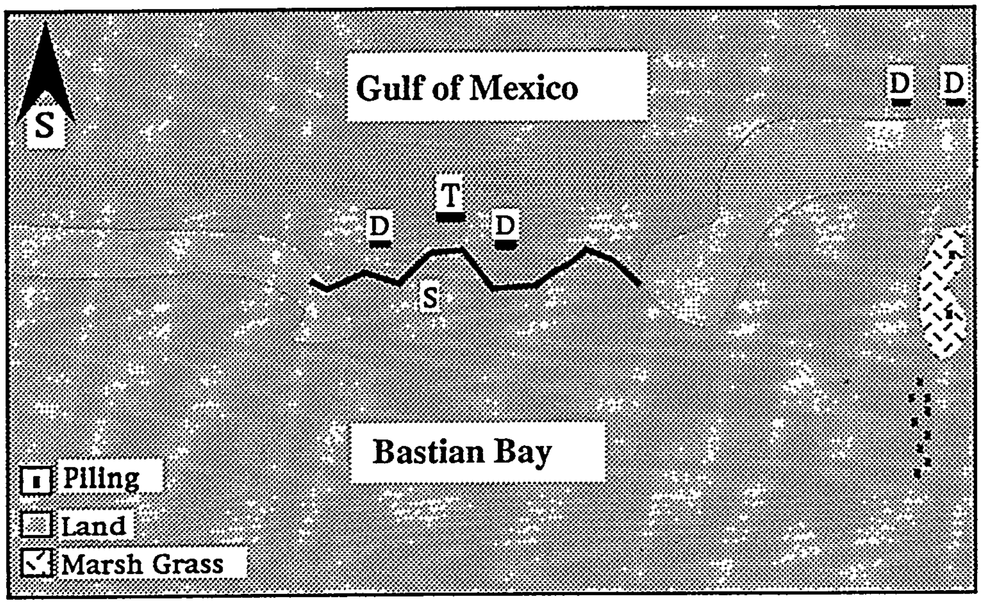


Figure 9. Site 7.

Site seven is located at a point along Shell Island where a shallow pass, six to twelve inches (15 to 30 cm) in depth at low tide, has developed. This site has a large sediment size, consisting of many shells and some sand. The waves impacting the area come from the Gulf without any obstruction resulting in a high wave energy relative to all other areas in the study. There are also waves impacting this site from the north from Bastian Bay. Over a period of two weeks, four two-high pyramids, one three-high pyramid and one long single-file were placed at this site. It important to note that this includes two 19 cone pyramids placed west of the gap on the Gulf side of the island. These are shown in the upper right of Figure 9. The single file of cones extended from the end of the island on the west side of the pass to the island on the east end of the pass in a zig-zag like pattern. At low tide, the tops of many of these cones were out of the water. Two nineteen cone pyramids were placed on the Gulf side of this row and still further out the three high pyramid consisting of thirty-six cones was placed.

Description of Study Two

There was only one test site in study two, which is located on Fourchon beach in South Louisiana. Fourchon is a sandy beach on the Gulf of Mexico, that has medium grain size combined with moderately high wave energy. An initial topological survey was taken during the two day period of beach cone deployment in December of 1992. The results of this survey together with the cone placement is shown in Figure 14. Four two high pyramids and two three high pyramids were deployed in the area. The pyramids were placed at different angles to the shore line with varying distances between them and the shore line and between each other. In February a second survey was conducted and in June of 1993 a third survey was performed. The changes in the topology of the beach, the amount of sediment gained or lost, and the degree to which the cones shifted and settled during the study were determined from these surveys. Although surveys were conducted at the site were cones were placed, lack of funds precluded the possibility of surveying a remote section of the beach without cones as a control. The Louisiana Department of Natural Resources provided funding for this study.

Discussion Of Field Results

Study One

The monitoring of the sites in Study One have shown a wide range of effectiveness. The morphological changes in the sites has ranged from the reappearance of an entire island to no change except the cessation of erosion. There is no evidence at any site in the study of the cones having an adverse effect on the ecosystem or on the site morphology.

The largest amount of change has occurred at Site 7. In late August of 1992, Hurricane Andrew destroyed the island to the east of the pass. The island to the west of the pass showed little damage from the storm. There was no indication that the storm altered the configuration of the cones. The condition of Site 7 after the hurricane is shown in Figure 10. The survival of the beach cones through Hurricane Andrew is a good indication of the stability of the structures under very high energy waves.

A few weeks after Andrew passed, a significant buildup of sediment at the eastern end of the zig-zag pattern was noted. On November 27, 1992 a visit to the site revealed a significant buildup of shell size sediment just to the north of the cone installations. By December 4, 1992 this area had grown to a size of 25 by 40 feet (7.62 by 12.19 meters) at a height of sixteen inches (40.6 cm).

Continued observations revealed that this sediment was moving northward. The island at the west end of the zig-zag was also extending to the north. By the middle of May 1992, a new island north of the cones and a new island east of the cones had appeared. The island to the east is most likely a result of the first noted buildup moving to the northeast and growing. This growing island was not seen during the February examination due to very high tides. The island to the west had detached from the cones and was continuing to move north. Very little change was observed between May, 1993 and March, 1994. On April 20, another reconnaissance trip was made to the experimental sites at which time a startling development was observed at Site 7. The gap in the island where the beach cones were placed had become a solid land mass along with the western part of the island that had disappeared during Hurricane Andrew. Apparently a storm (or perhaps several storms) had provided exactly the wave action required to transport material (mostly oyster shells) at an angle where vertical buildup could occur. It is suspected that the underwater dune caused by the beach cones caused waves to break at a critical point such that buildup could occur. Unfortunately, however, there is no way to *prove* that beach cones were responsible for this activity. The changes seen in Site 7 are summarized in Figures 11 to 14.

The fact that the original pass between the islands was not repaired is not considered a failure. To the contrary, the significant amount of accretion that has occurred since the passing of Andrew is a positive indication bet it is not possible to attribute this to the cones.

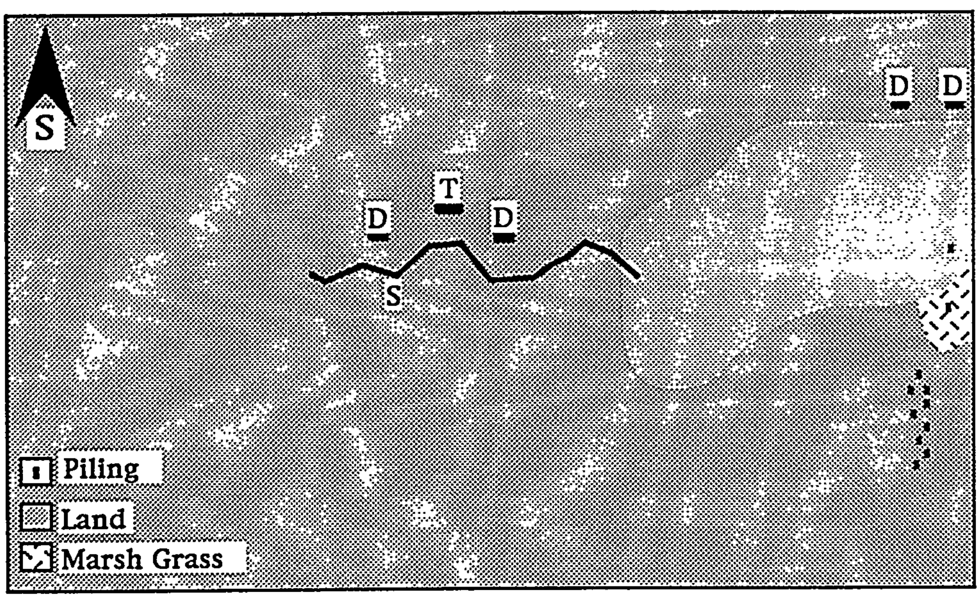


Figure 10. Site 7 after hurricane Andrew.

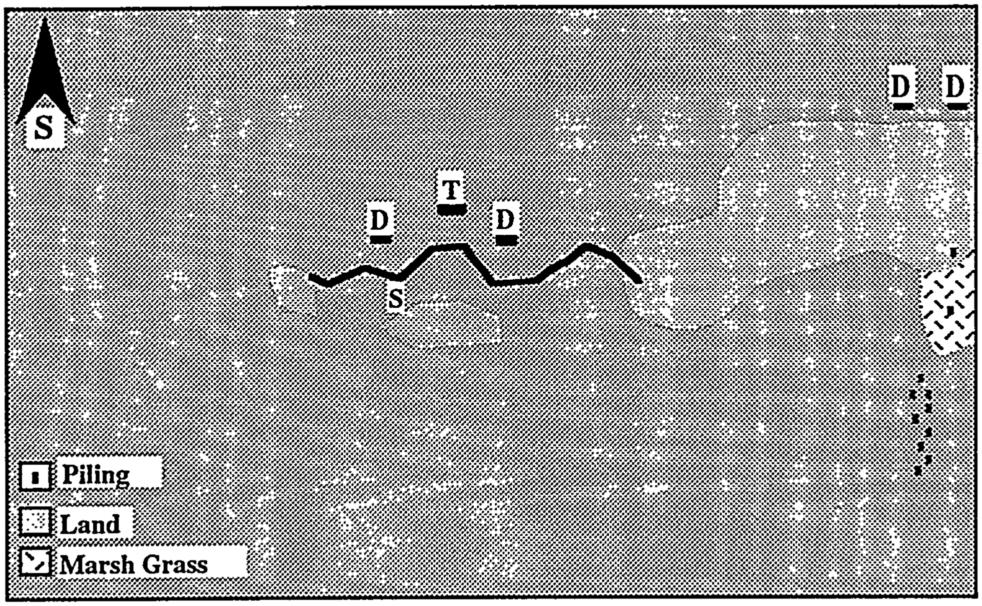


Figure 11. Site 7 December 4, 1992.

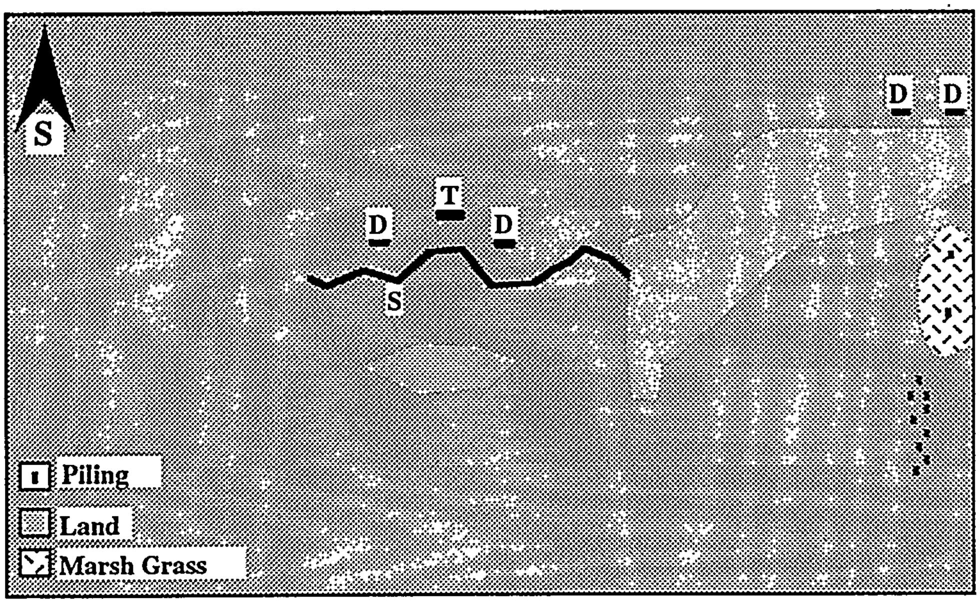


Figure 12. Site 7 February, 1993

1993

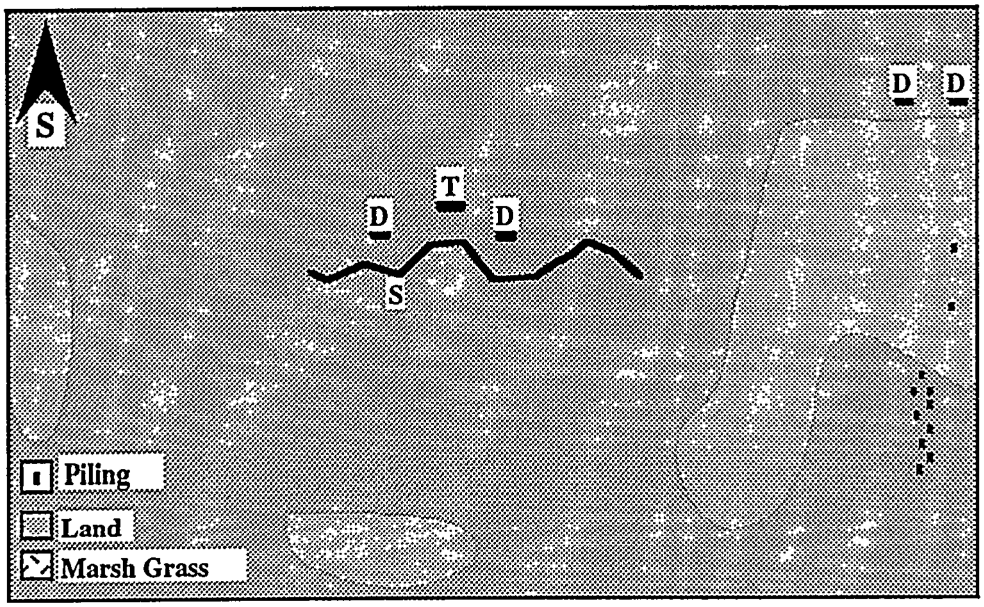


Figure 13. Site 7 mid May 1993.

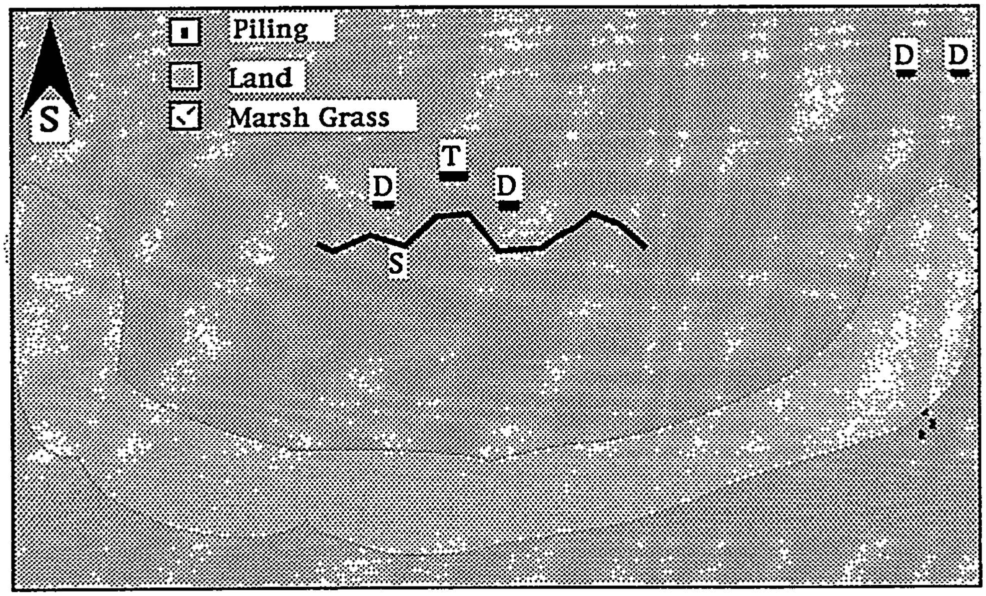


Figure 14. Site 7 March 1994.

The only other sites to show accretion in Study One were Sites 1 and Site 2. Site 1 had a slight build up of sediment on the south side of the cones on November 27, 1992. Site 2 was observed to have a buildup on the marsh side of the two pyramids to the north on November 27, 1992. The other sites in Study One have shown no accumulation to date, but importantly there has been no further erosion.

Table 2 ranks the sites, including the one in Study Two, according to amount of sediment accumulated. The current referred to is one other than those resulting from obliquely incident waves, which are present at all the sites. It appears that the best conditions for beach cones are moderate to high wave energies combined with a sandy beach. The area of least impact occurred with small or medium energy waves combined with small or medium grain size. However, as noted earlier, even some of these sites showed slight accretion, and none of them showed continued erosion. Table 2 indicates that the incident wave energy is the predominant factor in determining success or failure. The effect of currents in the area is not apparent and needs further study.

Table 2. Sites Ranked by Overall Effectiveness of Cones

Site	Wave Energy	Particle Size	Current
Fourchon	High	Medium	none
Seven	High	Large	none
One	Medium	Medium	yes
Two	Small	Small	yes
Three	Medium	Small	yes
Four	Medium	Small	yes
Six	Small	Medium	none

Study Two

The initial survey of the Fourchon beach is shown in Figure 15. The cone pyramids are shown as dark ovals. It can be seen that the contour lines are all roughly straight and parallel to the shoreline, which is at the 3.0 ft. (0.9 m) contour during mid tide, except for around the -1.5 ft. (-0.45 m) contour. The variance of the -1.5 ft. (-0.45 m) contour is explained by the presence of a large pipe running across the contour lines in the point at which the -1.5 ft. (-0.45 m) contour abruptly changes.

The second survey is shown in Figure 16 from which it can be seen that the general shape of the contours is the same but those less than 3.0 ft. (0.9 m) have shifted south east by about 25 ft (7.6 m). Also, the contours around 0 ft. have moved further apart. This is an indication that the overall slope of the beach is decreasing. Those contours higher than 3.0 ft. (0.9 m), the shore line at mid tide, only moved slightly. The fact that all of the contour lines remained generally straight and parallel without abrupt changes in direction indicates that the cones were functioning in a manner that allowed each pyramid's effect on the topology to overlap with its neighbors.

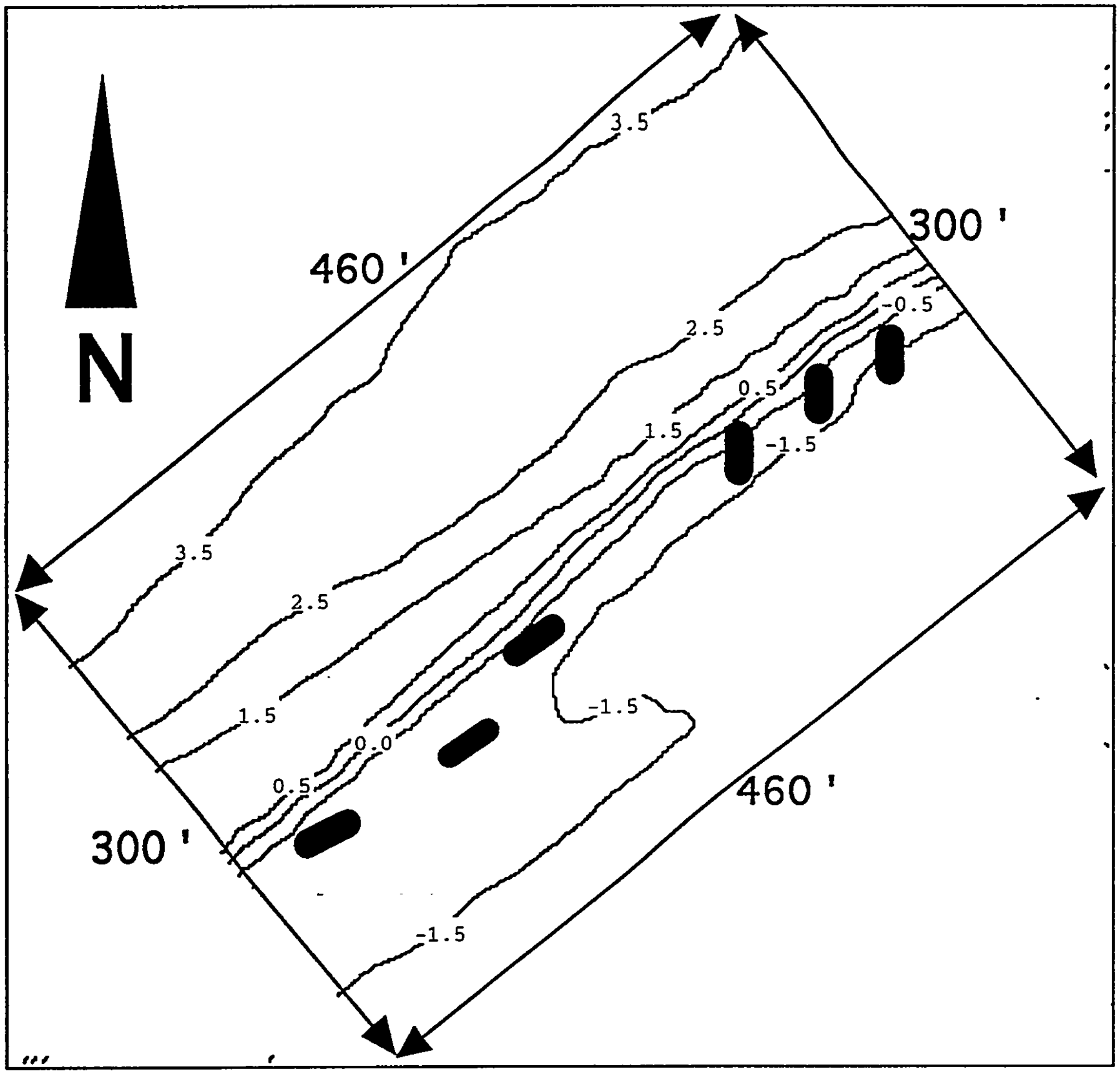


Figure 15. Fourchon Beach December 1992.

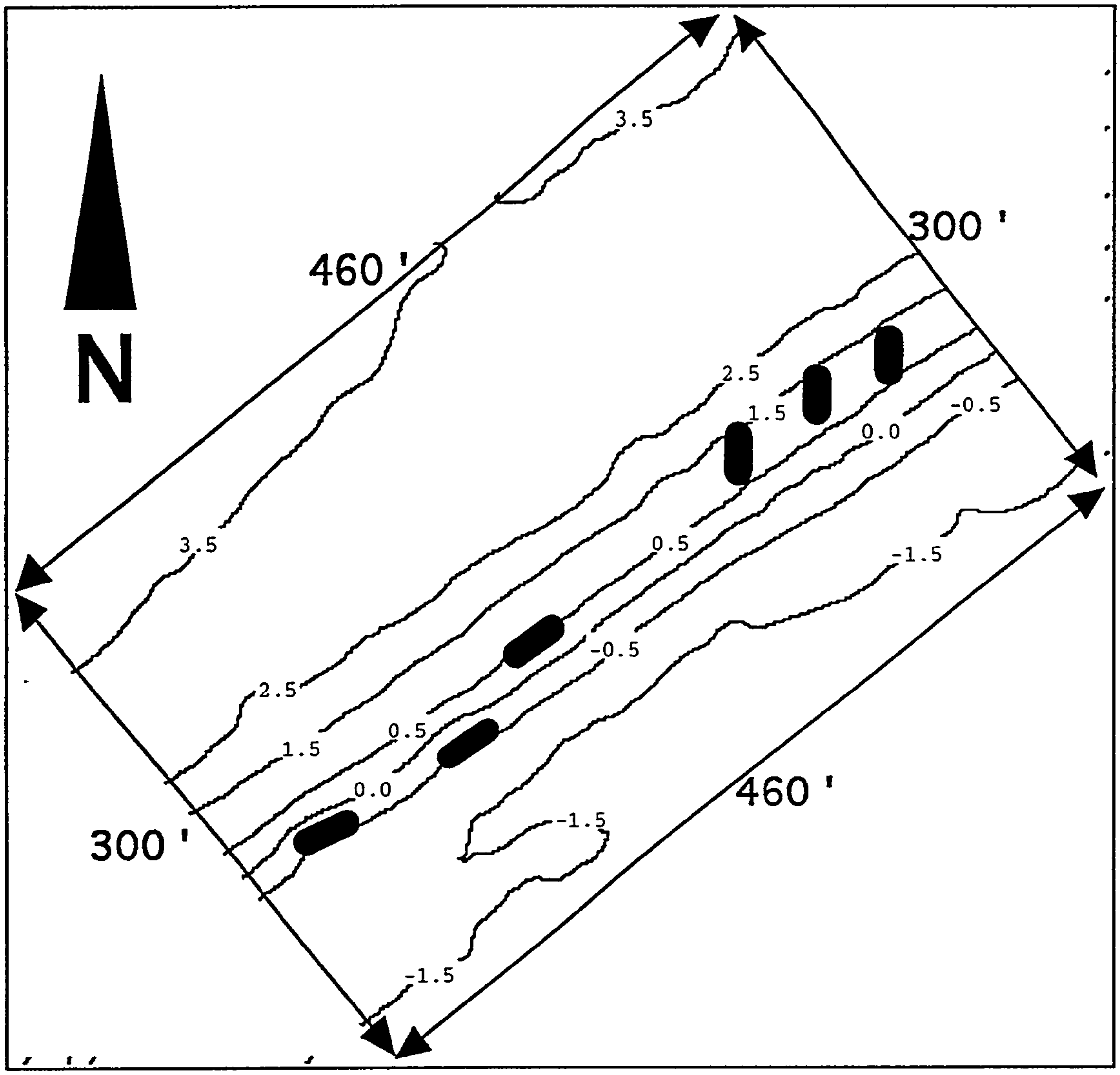


Figure 16. Fourchon Beach February 1993

In an effort to better assess the effectiveness of the cones, a *difference* map of the December and February data was generated as shown in Figure 17. This map indicates that the accretion was greatest in the northeast section of the study area, in which up to 2.3 feet (0.7 m) of sediment was accreted. This is as expected because two of the three pyramids in this area were three cones high, and took longer to become completely covered. Figure 17 also shows a net loss of sediment in the southern most corner of the study area. However, the region between the two zero accretion contours is also the location of the pipe mentioned previously, which is believed to have affected the accretion in this area.

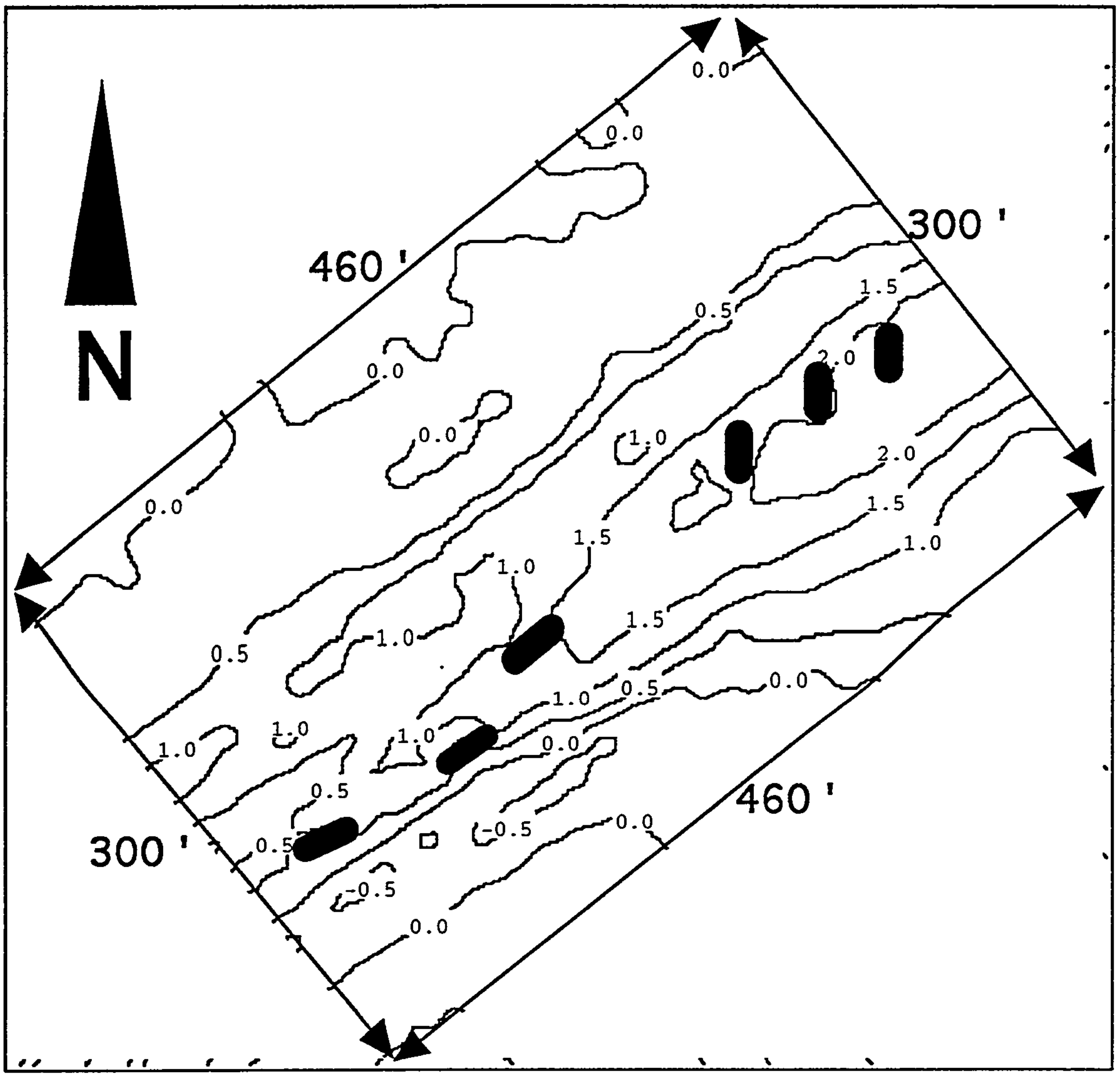


Figure 17. Fourchon Beach February '93 - December '92 Difference Map

The accretion region map shown in Figure 18 shows regions were sediment accumulation occurred in pink and regions were loss occurred in dark gray. This figure indicates that the area in which the cones would be expected to have an effect, elevations below the mid tide line, showed only accretion. The one exception was the area in which the pipe was located. This indicates that the cones had a positive effect on the accretion in the area.

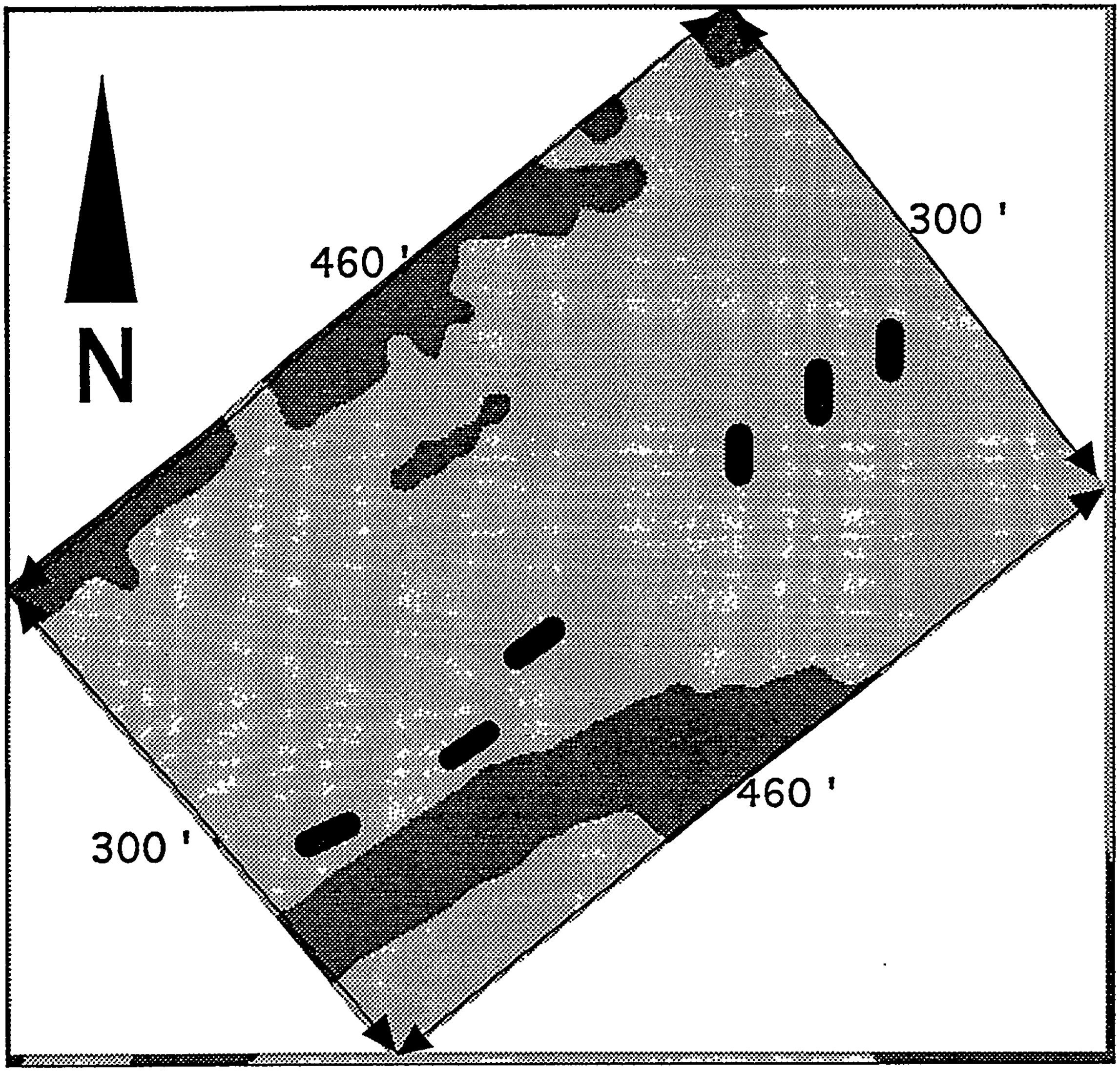


Figure 18. Fourchon Beach February '93 - December '92 Accretion Region Map

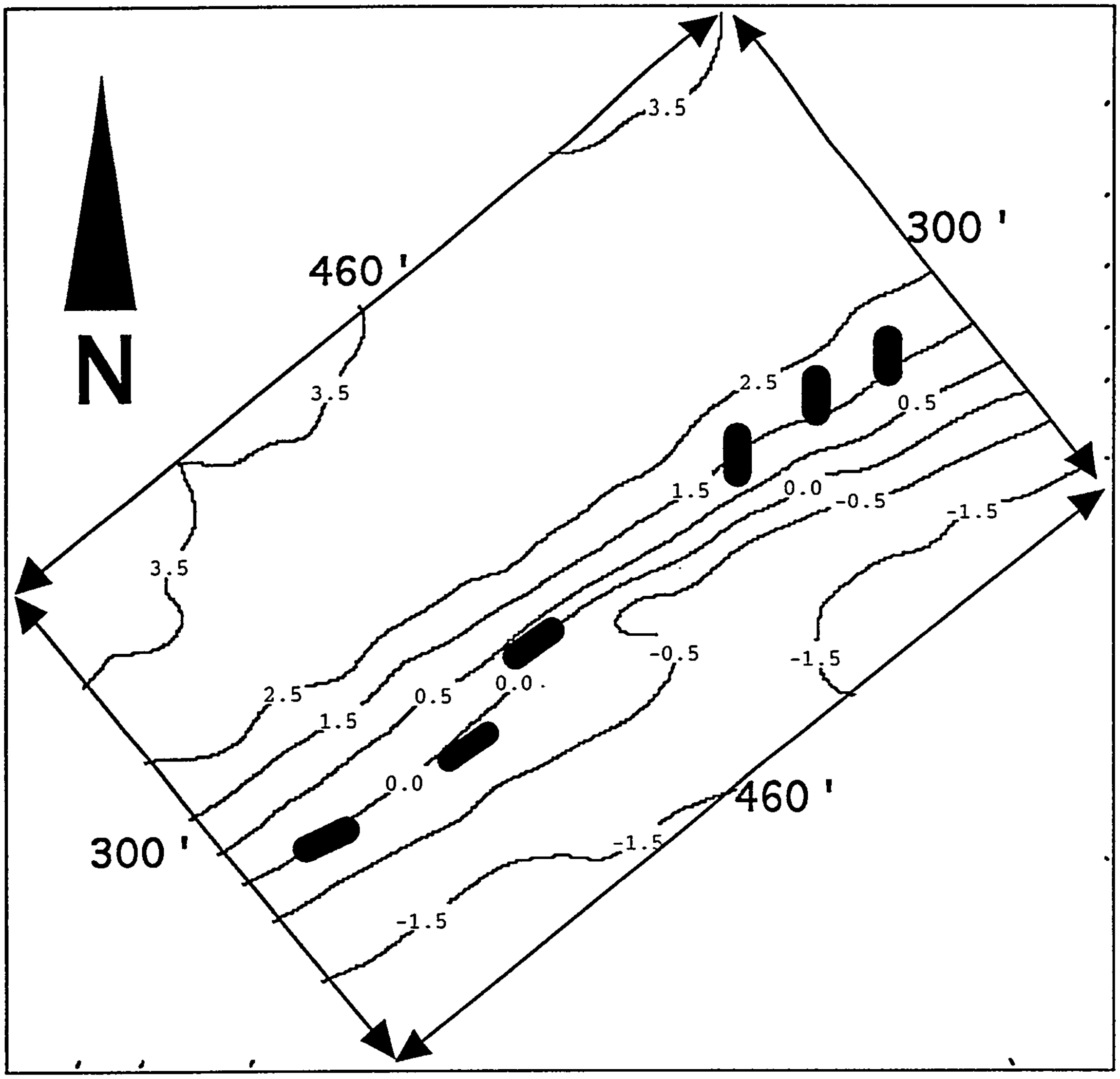


Figure 19. Fourchon Beach June 1993

A third survey was done in June of 1993 and is shown in Figure 19. The contour lines taken during this survey vary little from those taken in the February survey. The *difference* map shown in Figure 20 indicates that there was little accretion during this time. These results indicate that the overall changes in the area were small during the February to June period. The measured volume change for the February to June period of 450 cubic meters (600 cubic yards) compared to that of the December to February period of 2200 cubic meters (2900 cubic yards) is further indication that the change during this period was small compared to the previous period.

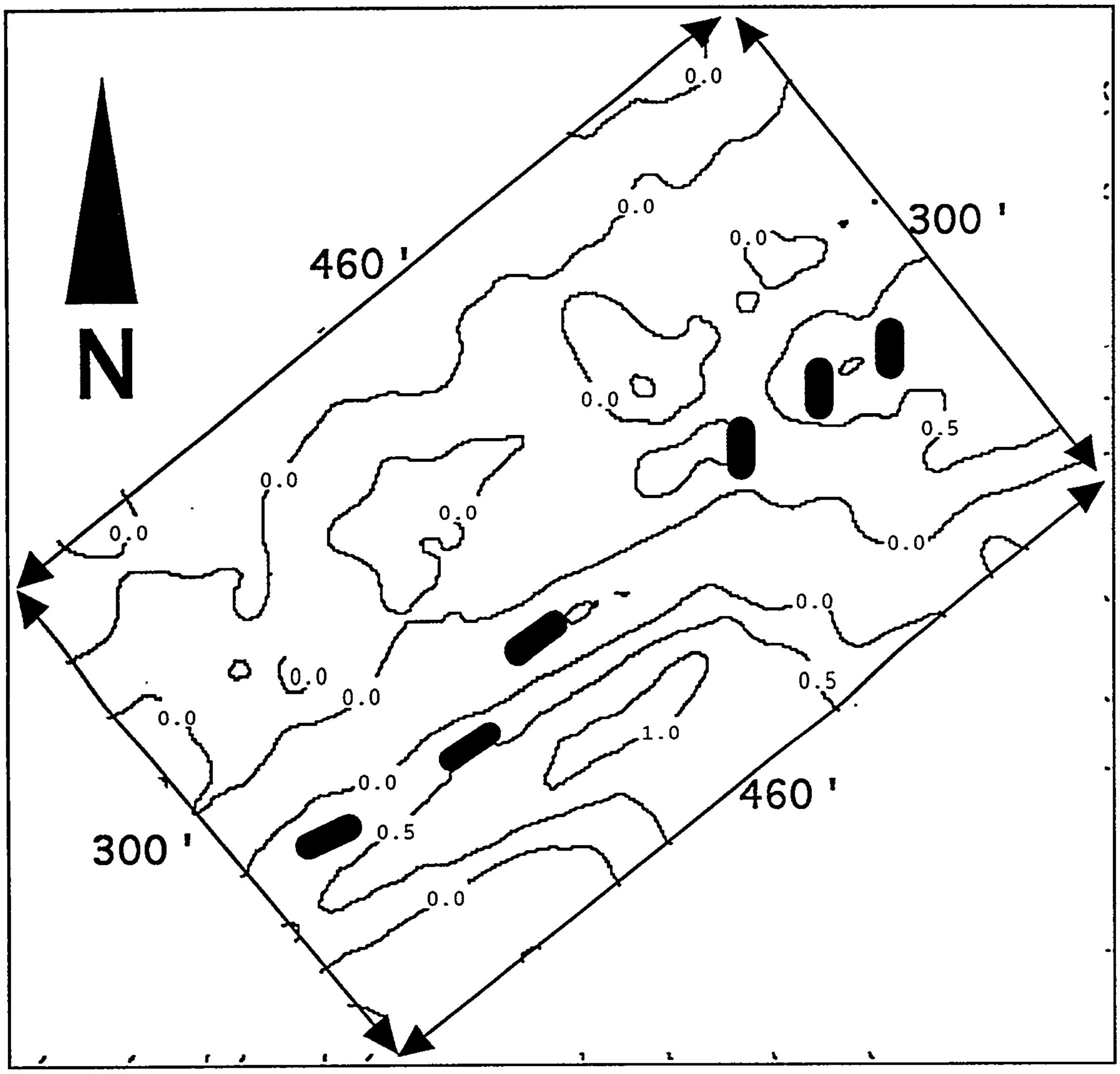


Figure 20. Fourchon Beach June '93 - February '93 Difference Map.

The difference map and accretion region map for the over all December to June period are shown in Figures 21 and 22. They appear to be very similar to the December to February data but different from the February to June data. This is taken as strong evidence that the changes in the area from December to June occurred almost entirely during the December to February time frame. Since the cones were found to be completely covered during the February survey, they would be expected to have effected the accretion rates only during this period. The rate of accretion was roughly 1450 cubic yards per month between December and February, when the cones would have had an effect, and 200 cubic yards per month between February and June when the cones had no effect. If the accretion rates during the second time frame are assumed to be due to some natural background accretion the cones have demonstrated the ability to increase the accretion rate significantly. Figure 23 shows an accretion map for the entire period of study.

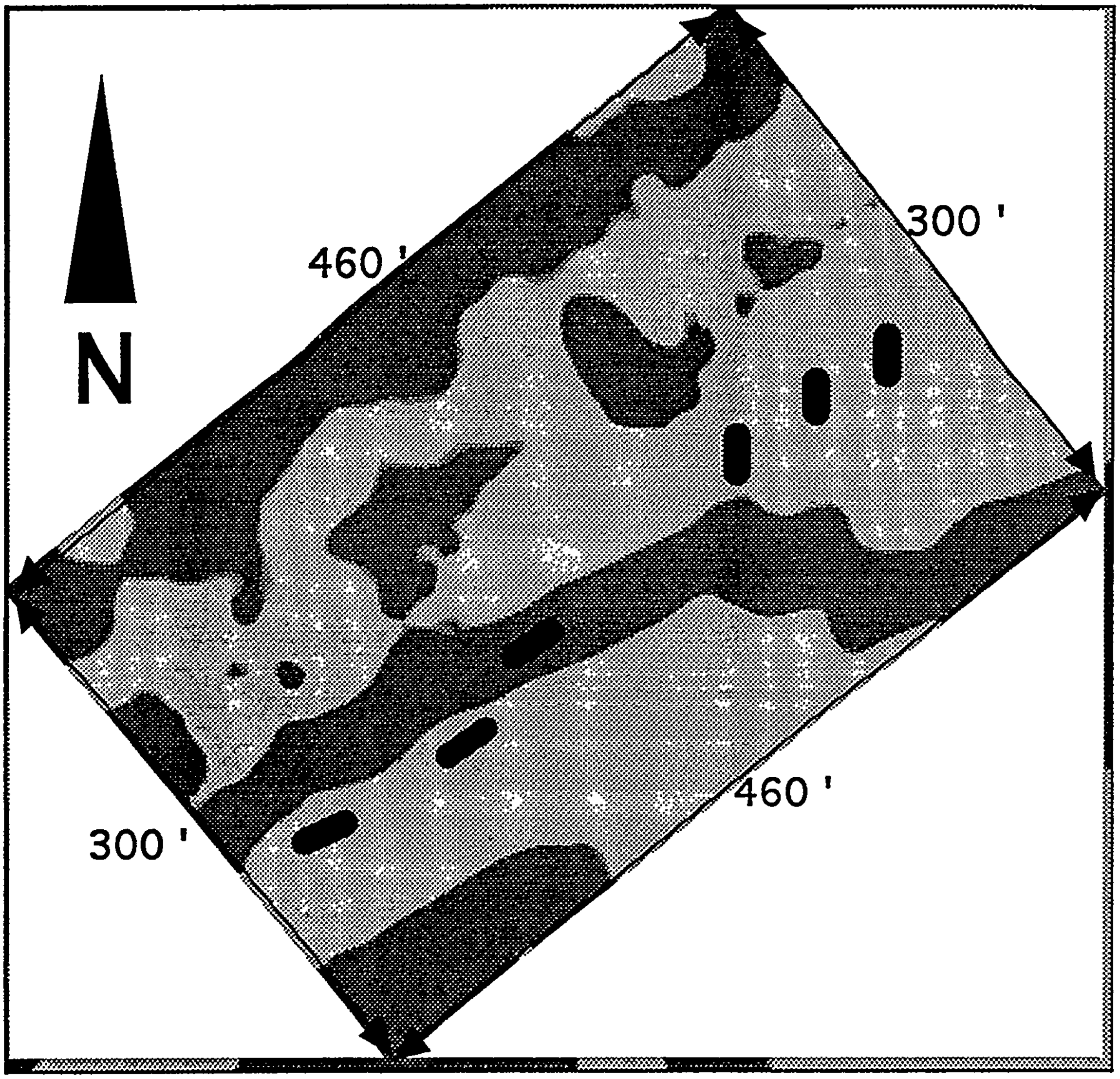


Figure 21. Fourchon Beach June '93 - February '93 Accretion Region Map

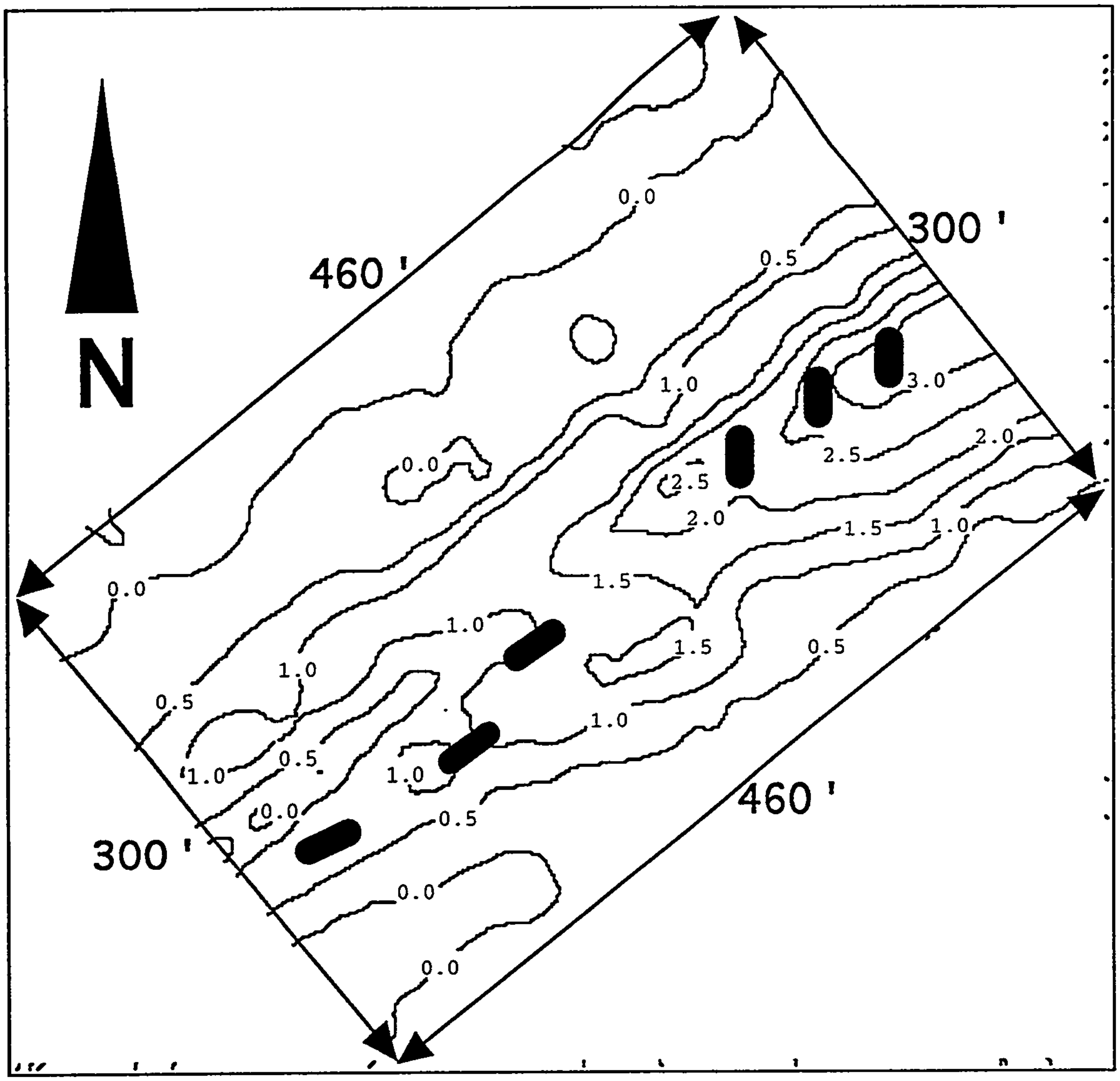


Figure 22. Fourchon Beach June '93 - December '92 Difference Map.

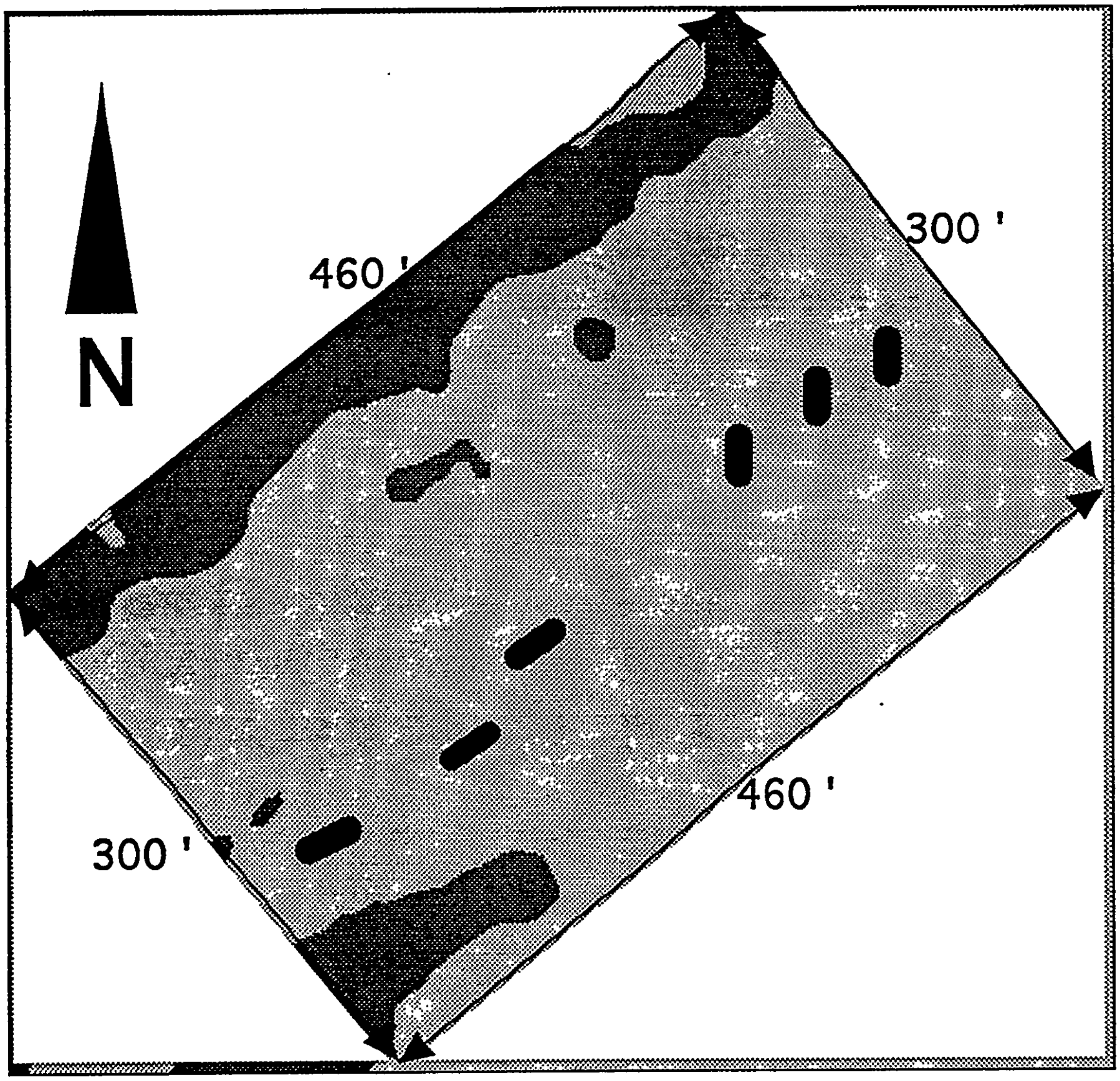


Figure 23. Fourchon Beach June '93 - December '92 Accretion Region Map.

In addition to sand elevations, the elevation of the tops of the pyramids was taken in the surveys at Fourchon beach. This information is summarized in Figure 24. There were two sets of measurements taken on pyramids one and six. The numbering of the pyramids is from lower left to upper right in Figures 15 to 23. The average change in these eight points is a loss of one fifth of a foot (0.06 m) in elevation. The maximum loss was three fifths of a foot (0.18 m) at one point on pyramid one while no change was found at pyramids three and six. This indicates that while the cones may settle in soft sand they do not sink faster than sediment is accreted over them.

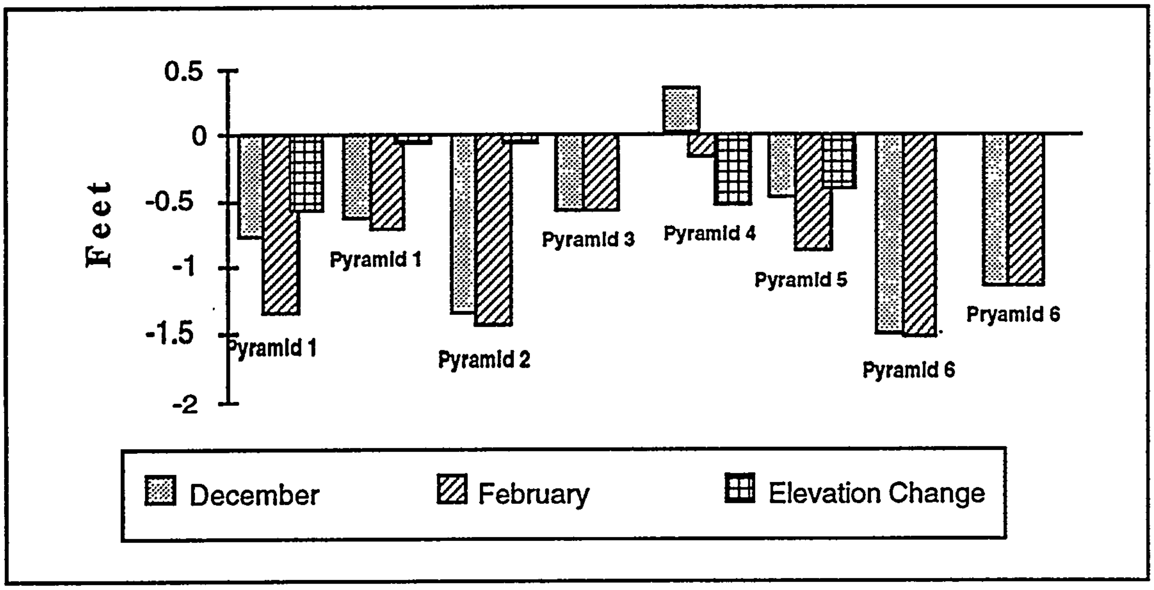


Figure 24. Top of Pyramid Elevations.

Economic Analysis

The cost of beach restoration using beach cones can be crudely estimated from the data taken from Fourchon. The cost for the six beach cone installations located at this area was $40,000, which included not only the cost of the beach cones themselves (approximately $180 per cone and wave block), but also taxes, transportation, labor, additional materials, profit, and overhead. 2900 cubic yards (2200 cubic meters) were accreted in the area at a cost of $13.79 per cubic yard ($17.95 per cubic meter) for the December to February time frame. However, comparison of cost verses benefits for this study are not completely accurate, there may be accreted material further out in the Gulf.

If the beach cones were mass produced, the unit price of a beach cone and wave block could be reduced to about $30. If all other costs are assumed constant, the overall cost would be reduced to about $20,000 from $40,000 for the Fourchon installation. This translates into a unit cost of about $7.00 per cubic yard or $9.00 per cubic meter.

Description of Installation Process

The cones are installed in a pyramid formation with the aide of a metal frame. This frame, shown in Figure 26, is made of aluminum pipes of a large enough diameter to drive PVC pipe through. The pipes are arranged on the frame with the same spacing which the PVC pipe will ultimately have in the pyramid. The frame is placed on the bottom were the pyramid is to be installed, and PVC pipe is driven through the aluminum pipes. Beach cones are placed around the frame as shown in Figure 25. After the frame has been removed the wave blocks are placed over the PVC pipes and slid down to the level of the beach cones.

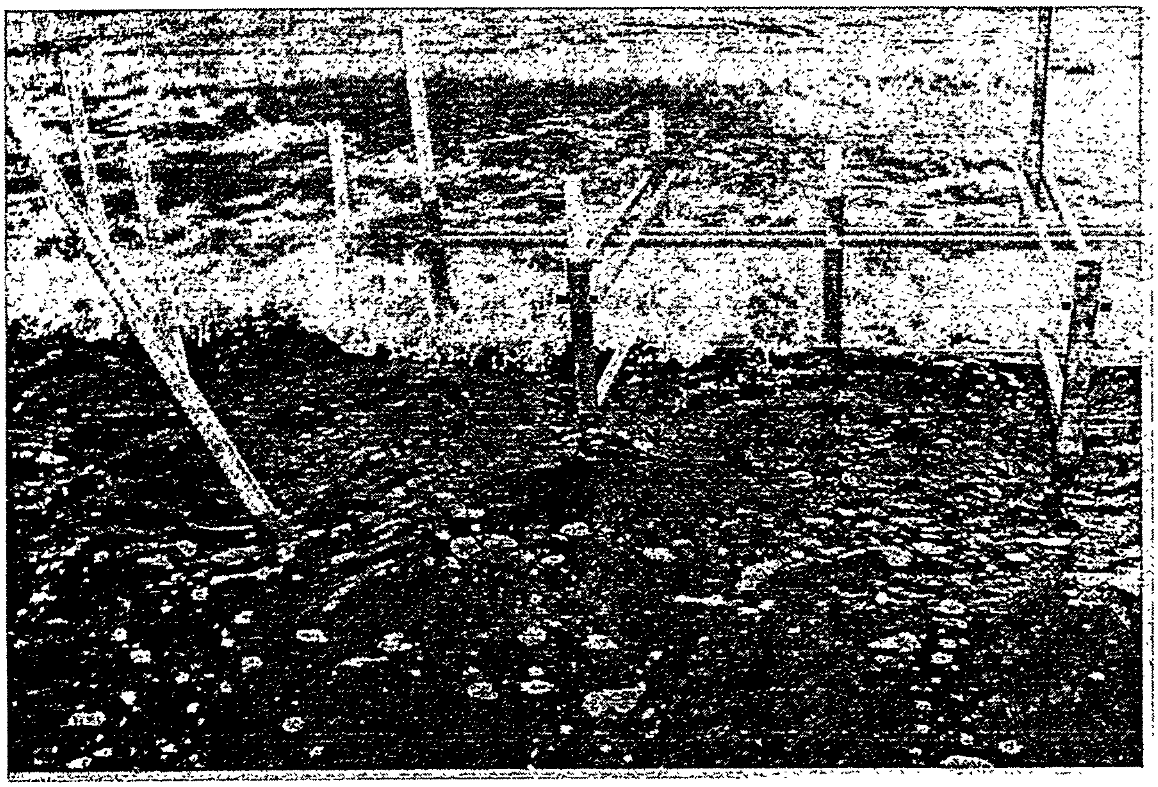


Figure 25. Aluminum frame used during cone installation.

Once the first layer has been completed in this fashion the second and third layers of the pyramid are placed using the PVC pipe as guides for the positioning of the cones and wave blocks. After the entire pyramid has been placed caps are put on to the PVC pipe and the pipes are driven down to the tops of the wave blocks. The result is a structure such as the ones shown in Figures 26 and 27.

The placement of a single file row of cones can be accomplished without the aide of the frame. First the row of cones and wave blocks are laid in the position desired then the PVC pipe is driven though the wave blocks as shown in Figure 28.

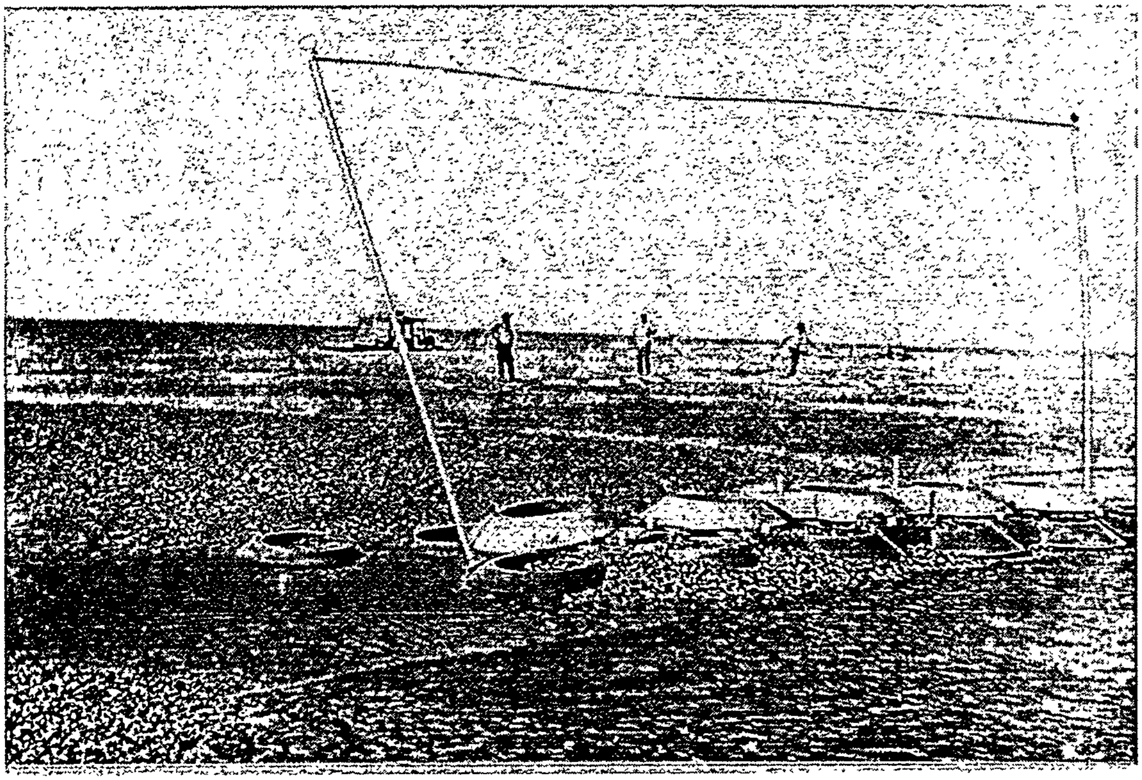


Figure 26. Competed Two Layer Pyramid (Note Accretion in Background).

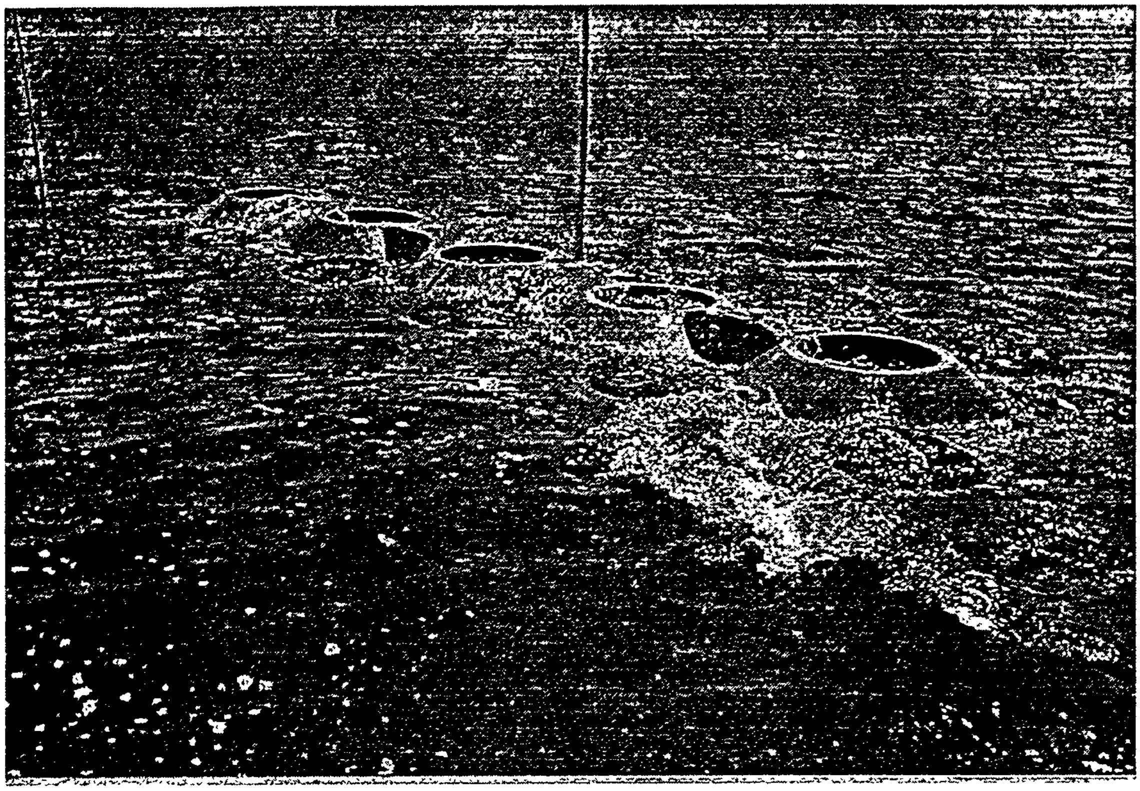


Figure 27. Completed Three Layer Pyramid

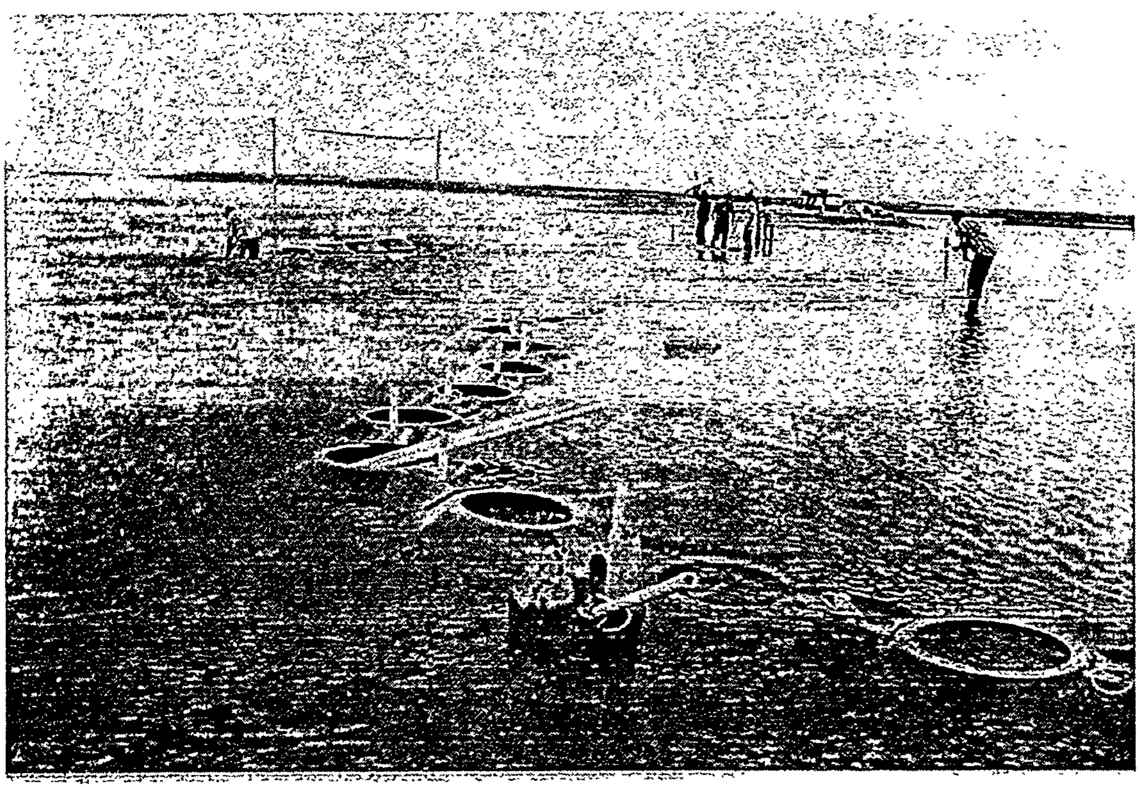


Figure 28. Placing Cones and Wave Blocks in Single File.

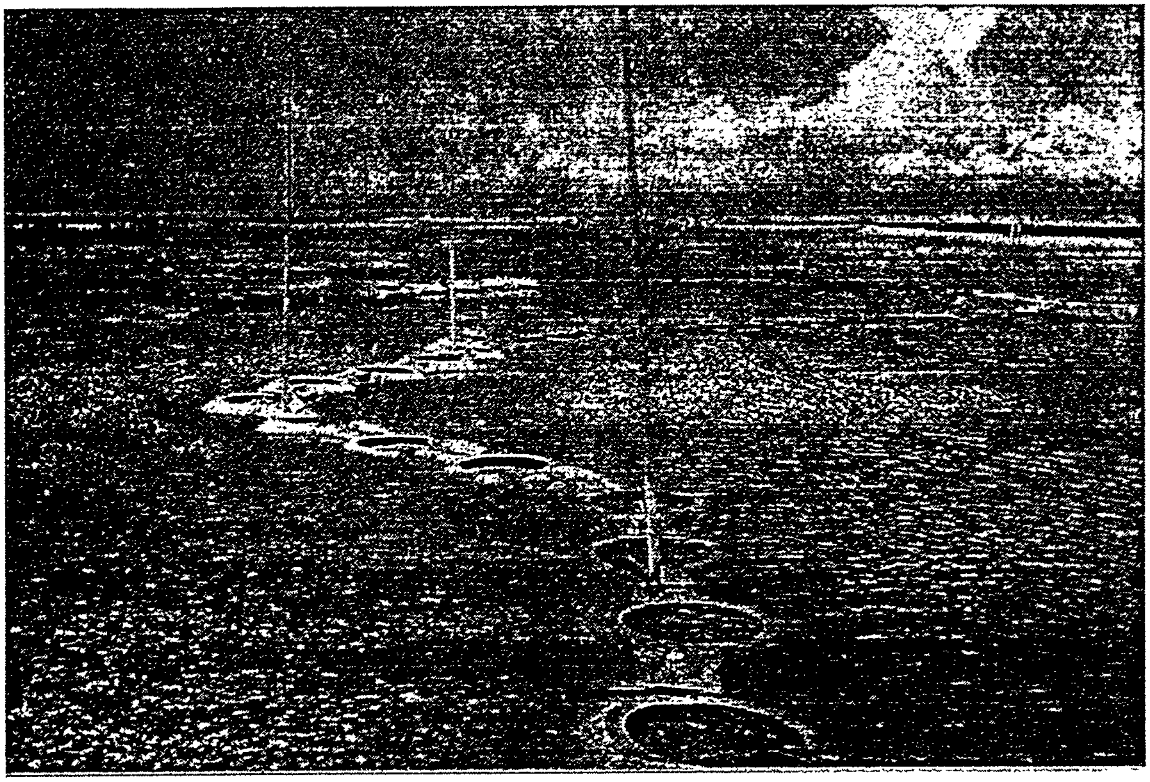


Figure 29 Site 7 Upon Completion of Installation.

Conclusions

Based on this study the following conclusions can be drawn.

1. Beach cones can have a noticeable effect on erosion rates. The ideal conditions for their use would be medium to high wave energies with sandy beaches. A breach in a barrier island has been repaired in the neighborhood of a large beach cone installation.

2. The cost beach of cones is favorable when compared to that of conventional beach restoration methods. A conservative estimate from Study Two indicate that the cost per cubic yard accreted is $14 ($18 per cubic meter) based on actual costs. If the beach cones were mass produced, the overall cost could be reduced to about $7 per cubic yard accreted ($9 per cubic meter).

3. The structure of the cones is strong enough and they can be anchored sufficiently to survive significant storms.

4. While the cones settle in soft sand, it has been demonstrated that this effect is not great enough to hinder their effectiveness. The average settling was 0.2 ft. (0.06 m.), while the average accretion was 0.6 ft. (0.18 m).

5. Based on visual inspections, there have been no detrimental effects to flora or fauna from beach cone use.

Recommendations for Future Research

1. Further research into the effects of grain size and wave energies should be undertaken. This can be done by installing cones in identical configurations and spacing at several sites which vary in incident wave energy and grain size. The main difficulty, other than cost, with this approach seems to be the difficulty in locating sites with similar wave energies but different grain size or vice versa. Most beaches have already undergone a natural sorting process which result in a given grain size becoming predominant at beaches with the same wave energies. One solution to this problem would be to place the cones on a section of beach that has been reclaimed using current methods and on a section of the same beach that has not been reclaimed. Thus, because dredged sand almost never exactly matches the natural beach sediment, the grain size at the two sites would be different, while the wave energies would be comparable.

2. The accumulation rates should be determined. This would consist of several long term studies which have detailed topological maps taken before installation of the beach cones and every two to three weeks thereafter. This could be done in conjunction with the studies recommended above.

3. Other configurations of cones should be examined, such as **L** shaped pyramids. Again this could be done in conjunction with the experiments suggested above.

4. The effects of local currents due to rivers, streams, and bayous should be studied further. The amount of sediment placed in the near shore system due to these flows is significant. Thus, a more complete understanding of current effects will be essential in the optimization of using beach cones in such a setting.

Acknowledgments

This research has been supported by the generous contributions of the U.S. Department of Energy and Freeport McMoRan through contract number DE-AC22-92MT920002 and the Louisiana Department of Natural Resources. We especially wish to recognize the efforts of Dr. Brent W. Smith Mr. Jerry D. Ham of the Department of Energy Metairie Site Office, Mr. Garland Robinette, Mr. Roy Pickren, and Mr. Don Chamberlain of Freeport McMoRan, Inc., and Mr. George Boddie of the Louisiana Department of Natural Resources. Recognition should also go to Dill Construction (especially Mr. James Dill), without whom the placement of the cones in and around Bayou Cook would have been a much more difficult task, and to Delta Marina (especially Mr. James Martinez) whose patience and assistance during the study is greatly appreciated. Finally, we wish to recognize the efforts of Mr. William Mouton, one of the beach cone inventors, who was instrumental in both the construction of the beach cones and in their placement.

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Appendices

1. Detailed Project Status
2. Subcontractor Report from Xavier University
3. Subcontractor Report from Louisiana State University
4. Coastal Use Permit Application

Appendix 1: Detailed Project Status

1. On January 15, 1992, the Principal Investigator and Mr. William Mouton were piloted to the experimental sites in a small plane. Over 40 color photographs were taken of a variety of potential study areas. These photographs were needed prior to filing for federal and state permits.

2. On February 11, 1992, permit application was made to the Louisiana Department of Natural Resources (DNR). This application was filed in anticipation of a contract starting date in early March. By filing the application prior to formal contract signing, several weeks of valuable experimental time might be gained. A copy of the permit application is attached to this report.

3. On February 25, 1992, executives of Freeport McMoRan, Inc. (FMI) were shown the experimental sites by the Principal Investigator and Mr. Edward Davis (Research Assistant on the project). Recall that FMI is a cosponsor of this work. The group spent the prior evening at FMI's lodge in Port Sulfur, Louisiana and proceeded to Empire, Louisiana at 7 a.m. where the Principal Investigator's boat was launched. By 7:45 a.m. the group was observing Site 1 and the tour concluded at Site 7 at approximately 12 p.m.

4. On March 6 - 8, 1992, a reconnaissance trip to the sites was made with the Principal Investigator, Mr. Edward Davis (Research Assistant on the project), and Mr. Noel Brodtmann of Environmental Professionals, Inc. (EPL), one of the subcontractors on the project. Preliminary LORAN coordinates were taken at each of the experimental sites. It was subsequently concluded that the LORAN unit, which belongs to EPL, was not sufficiently accurate for the purposes of this project and a Global Positioning System (GPS) was obtained. This instrument was essential to proper mapping of the experimental sites prior to cone installation and for monitoring progress of sediment accretion after cone deployment.

5. On March 20, 1992, a 21 foot flat boat with trailer was leased for the duration of the project for $5,640. This boat will be the primary work vessel for ferrying personnel to the sites and for cone deployment. On March 24, this vessel was moved from New Orleans, Louisiana to a boat shed in Empire, Louisiana. At that time the boat was taken on a shakedown cruise where it performed flawlessly. The availability of this vessel at an extremely attractive lease rate will allow all field work to be performed within the specified budget.

6. On April 3, 1992, another reconnaissance trip was made with Mr. Brodtmann to observe the oyster populations at the various sites since the DNR had indicated that a full "Oyster Assessment" was likely to be required prior to obtaining permits. Subsequently, DNR did inform us that an Oyster Assessment was needed and EPL has initiated this study.

7. On April 10, 1992, coworkers from Louisiana State University (LSU) were taken to the experimental sites by the Principal Investigator and Mr. Davis. Below water soil core samples were taken at all sites along with samples of vegetation and above water soils. A summary paragraph submitted by the LSU personnel is attached to this report.

8. On April 13, 1992, the Management Plan was submitted to DOE. This report was prepared by the Principal Investigator during the period from April 1 through the time of submission.

9. On April 24, 1992, the Principal Investigator and Mr. Davis accompanied Mr. Brodtmann where oyster assessment was performed at Site 1, Half Moon Bay. See the attached permit application for a more detailed description of all seven experimental sites.

10. Staring in December, 1991, forms were built by Beach Cones Research, Inc. for making the beach cones and connecting wave blocks. By the end of April, 1992, the required 600 cones for this project had been manufactured and are in storage awaiting deployment.

11. The Principal Investigator worked with a DOE support contractor in the preparation of an Environmental Report.

12. On May 1, 1992, the PI took the Xavier University co-investigators to the test sites where they sampled the flora and above water soils. A copy of their summary paragraphs pertaining to their activities is attached to this report.

13. On May 4, 1992, a permit was obtained from the U. S. Army Corps of Engineers. A copy of that permit is attached to this report.

14. On May 5, 1992, the PI met with representatives of C. L. Dill Construction Company. Freeport McMoRan has agreed to hire Dill Construction to transport the beach cones from their dock in Empire, Louisiana to the study sites by barge.

15. A letter of "no objection" was received from the State of Louisiana, Department of Health and Hospitals. This letter is dated April 15, 1992 but was not received by the PI until May 6, 1992.

16. On May 22 - 24, 1992, a reconnaissance trip to the sites was made by the PI and Mr. Edward Davis (Research Assistant on the project). GPS readings and depth sounding data were recorded at Sites 6 and 7. Mr. Davis subsequently entered these data into a database

17. On June 3, 1992, Mr. Brodtmann of EPL submitted the finalized Oyster Assessment, a copy of which is attached to this report.

18. On June 9, 1992, a permit to proceed with field installation of beach cones at the proposed sites was obtained from the Coastal Management Division of the State of Louisiana Department of Natural Resources. This was the culmination of several month's effort.

19. On June 7 - 9, 1992, work on the initial survey of all experimental sites was completed. These data were entered into a database.

20. Further discussions were held at various times with C. L. Dill Contractors about transporting the beach cones by truck from New Orleans, Louisiana to Empire, Louisiana and then by barge to the experimental sites.

21. On July 3 and 10, 1992, the PI and Research Associate (RA) visited the proposed test sites to finalize cone placement where possible.

22. On July 17, 1992, the first shipment of approximately 84 beach cones and 96 wave blocks were trucked from the beach cone plant in New Orleans, Louisiana to the yard of C. L. Dill construction company in Empire, Louisiana. The cones and blocks were loaded onto a 120' x 40' spud barge.

23. On July 20, 1992, the spud barge was moved by tug boat to Site 1 and two pyramids of 19 beach cones were installed in a gap that was created by erosion of the marsh land.

24. On July 21, 1992, the spud barge was moved by tug to Shell Island, Site 7, and two pyramids of 19 cones were installed in a gap in the island that was created originally by Hurricane Juan.

25. On July 22, 1992, a shipment of approximately 132 beach cones and wave blocks were shipped by truck to the Dill yard in Empire.

26. One July 22 and 23, 1992, the PI and RA assisted Freeport McMoRan personnel with the filming of the proposed experimental sites and other subjects to be used in a television commercial. Freeport McMoRan was a joint sponsor of this project and their involvement was based on their ability to use project activities in their commercials.

27. On July 24 and 25, 1992, seven pyramids of 19 cones were constructed in Bayou Cook, Site 2. Five pyramids were placed in front of a lagoon that has grown by a factor of 10 in the past five years due to marsh erosion. The other two pyramids were built in front of a gap in the marsh created originally by a marsh buggy (associated with oil and gas exploration) and which has enlarged considerably within the last 10 years.

28. On July 27, 1992, a shipment of approximately 132 beach cones and wave blocks were shipped by truck to the Dill yard in Empire.

29. On July 28, 1992, approximately 30 beach cones and wave blocks were laid single file around a rapidly eroding marsh area at Site 2.

30. On July 29, 1992, the remainder of the cones and wave blocks on the spud barge were unloaded at Site 3, North Shore of Bastian Bay and at Site 7, Shell Island.

31. On July 30, 1992, one pyramid of 19 cones was constructed at Site 3 and a single file zig-zag arrangement was started at Site 7. On this same day, a shipment of approximately 84 cones were shipped to the Dill yard and loaded onto the spud barge.

32. One July 31, 1992, the 84 cones were unloaded on the shore at Site 7 and the zig-zag was completed.

33. On August 3, 1992, the remaining 252 beach cones were loaded onto trucks, delivered to the Dill yard and loaded onto the spud barge.

34. On August 4, 1992, cones were off-loaded at Site 7 where an additional pyramid of 19 cones was constructed along with a "triple" of 38 cones.

35. On August 5, 1992, two pyramids of 19 cones were installed at Site 6, North Shore of Shell Island Bay.

36. On August 6, 1992, approximately 20 cones were installed in a single file manner along the shoreline of a cove at Site 4, Single Pipeline Canal.

37. On August 7, 1992, the remainder of the cones were off loaded and installed single file along the shoreline of Site 2.

38. Reconnaissance trips were made to the sites on August 11 - 12 and on August 19, 1992.

39. A reconnaissance trip was made to the sites on August 29, 1992, just after Hurricane Andrew. It was encouraging that all cones were still in place except for a very few at Site 7 (Shell Island), which had simply moved a few yards. On the other hand, an entire segment of Shell Island just to the East of the test site had disappeared. This was most distressing since that piece of the Island represented our control area for elevations, it will now be impossible to precisely measure the changes in elevation at Site 7. However, suitable approximations can be made from other reference points, such as pilings, that were not disturbed by the Hurricane.

40. Reconnaissance excursions were made to the sites on September 8, 15, and 25, 1992. The September 25 trip was after a strong Northeasterly storm and showed a significant buildup of shell and sediment at the Easternmost end of the Shell Island test site. The shell and sediment appear to have come from that which washed away during Hurricane Andrew from a portion of the island where no beach cones were deployed.

41. On October 16, 1992, a reconnaissance trip was made to the experimental sites. Since the tide was high, we could only wade in several inches of water to try to observe the state of the beach cones. All cones appeared to be in their proper place. It was not possible to observe any accretion but clearly no erosive effects had taken place.

42. On October 30, 1992, another reconnaissance trip was made to the experimental sites. Weather conditions similar to those of October 16 existed and prevented any detailed observation of progress or lack thereof.

43. On November 6, 1992, a reconnaissance trip was made to the experimental sites. Since the tide was high and the temperature was low, we could only visually observe the state of the beach cones. It was not possible to observe any accretion but clearly no erosive effects had taken place.

44. On November 13, 1992, a reconnaissance trip was made to the experimental sites. Once again the tide was high and it was very cold, so we could only visually observe the state of the beach cones. The water was murky and it was impossible to draw any conclusion about the status of the project.

45. On November 27, 1992, a reconnaissance trip was made to the experimental sites. Finally conditions were such that we could observe that status of each site. No noticeable changes were observed at Sites 3, 4, and 6. There was a noticeable buildup of shells on the South side of the pyramids at Site 1 (Half Moon Bay) and on the shore side of some of the pyramids at Site 2 (Bayou Cook). At Site 7 (Shell Island) there was an impressive buildup of primarily shell on the North side of the experimental area (on the bay side rather than the sea side). We attribute this to strong Northerly winds that would normally push this material to the sea side. The beach cone installation prevented this movement and trapped the shells, which is the desired effect.

46. On December 4, 1992, a reconnaissance trip was made to the experimental sites. Tide and wind conditions were not highly conducive to observation of the beach cones but there appeared to be no noticeable change since the November 27 trip.

47. On December 10, 1992, a cursory survey of the Shell Island site was made. Based on the level of the PVC pipes driven to hold down the beach cone pyramids and on notes made during the installation period of late July and early August, 1992, a rectangular area behind the cones (on the Bastian Bay side) measuring approximately 25 feet by 40 feet has accreted to a height approximately 16 inches above its original level.

48. On December 26, 1992, a reconnaissance trip was made to the experimental sites. Crude surveys at the Half Moon Bay site indicated a buildup behind the two pyramids of an area approximately 5 feet by 20 feet to a height about six inches above the original. At the Bayou Cook site, there was a noticeable accretion behind two of the seven pyramids similar in dimensions to the Half Moon Bay site. Tide conditions did not allow measurements near the other five pyramids in Bayou Cook.

49. On January 9, 1993, a reconnaissance trip was made to the experimental sites. The tide and wind was high and the temperature was low. The beach cones were not very visible at Shell Island but were easy to see but under water at the other sites. No major changes could be observed at any of the locations.

50. On January 18, 1993, a reconnaissance trip was made to the experimental sites. Once again the tide and was high and the temperature was low, so we could only visually observe the state of the beach cones. The water was murky and it was impossible to draw any conclusion about the status of the project.

51. On January 25, 1993, a reconnaissance trip was made to the experimental sites. Conditions still were not conducive to quality observations. However, no major changes could be observed.

52. On February 2, 1993, a reconnaissance trip was made to the experimental sites. The tide and wind was high and the temperature was low. The beach cones were not very visible at Shell Island but were easy to see but under water at the other sites. No major changes could be observed at any of the locations.

53. On February 19, 1993, a reconnaissance trip was made to the experimental sites. The tide and was low, but so was the temperature was low. The water was not very clear, so careful observations were not possible.

54. On February 26, 1993, a reconnaissance trip was made to the experimental sites with the express purpose of performing a survey at Shell Island with a surveyor's level. Our crew of the Principal Investigator and four graduate assistants went to the site at 8 a.m. and began to set up for the survey. When the Principal Investigator checked the water temperature and realized that at least one person would have to get into the water, and considering a very strong northwesterly wind, the survey was canceled and rescheduled for April when weather conditions should improve.

55. On March 5, 1993, a reconnaissance trip was made to the experimental sites. It was during this trip that the presence of a new land mass was discovered. This island portion is located about 50 meters to the North of that which was destroyed in August, 1992, by Hurricane Andrew. Generally poor weather and tide conditions prevented close examination.

56. On March 26, 1993, another reconnaissance trip was made to the experimental sites. Weather conditions similar to those of March 5 existed and prevented any detailed observation of progress or lack thereof.

57. On April 16, 1993, a reconnaissance trip was made to the experimental sites. It was observed that the new land mass at Site 7 had increased in height by about one foot.

58. On April 30, 1993, a reconnaissance trip was made to the experimental sites. The weather was so poor that Site 7 was not reachable with safety. A cursory examination of Sites 1 and 2 were possible and indicated no noticeable change.

59. On May 14, 1993, a reconnaissance trip was made to the experimental sites. Finally conditions were such that we could observe that status of each site. No noticeable changes were observed at Sites 3, 4, and 6. The previously noted buildup of shells on the South side of the pyramids at Site 1 (Half Moon Bay) and on the shore side of some of the pyramids at Site 2 (Bayou Cook) had been maintained. At Site 7 (Shell Island), a close examination was made of the new land mass that has appeared. It is approximately one-half the length of the island that was destroyed by Hurricane Andrew, but its width and height are comparable. Given that it is about 50 meters to the North of the original island, which was adjacent to the beach cone installation, it is impossible to confirm or deny that the beach cones had any effect on its accretion. We can state that no such land masses have appeared anywhere else along the shoreline of Shell Island.

60. On May 22, 1993, a short reconnaissance trip revealed no changes at any site since the May 14 visit.

61. On July 10, 1993, a reconnaissance trip was made to the experimental sites. Excellent weather conditions allowed close examination of all sites. No substantial changes were observed since the May 22 visit.

62. On July 24, 1993, another reconnaissance trip was made to the experimental sites. Once again close examination revealed no positive or negative activity since Spring.

63. On August 13, August 28, and September 11, 1993, reconnaissance trips continued to reveal no significant activity, which was expected since weather conditions had been mild and calm.

64. On October 16, 1993, a reconnaissance trip was made to the experimental sites. Excellent weather conditions existed but the tide was too high to gather any significant data.

65. On November 6, 1993, another reconnaissance trip was made to the experimental sites. High winds and tides prevented close observation of the installations.

66. On December 4, 21, and 30, 1993, reconnaissance trips were made and the tide and wind conditions were ideal for observing the cone installations at all but Site 7; the tide was so low that passage through Bay Bastian to the site was not possible. On December 4, camera problems prevented recording of the data, but on December 21 and 30, excellent video and 35 mm slides were taken, particularly at Site 2 where impressive accretion has occurred on and behind the cone pyramids along the shoreline and within the single file of cones placed in the eroding marsh.

67. On January 8, 1994, a reconnaissance trip was made to the experimental sites. Excellent weather conditions existed and video tapes were made of site 2.

68. On January 29, 1994, another reconnaissance trip was made to the experimental sites. High winds and tides prevented close observation of the installations.

69. On February 19, March 5, and March 26, 1994, additional reconnaissance trips were made. Good observations were possible at these times but no noticeable changes had occurred.

70. On April 8, 1994, a reconnaissance trip was made to the experimental sites. Only Sites 1 and 2 were observed since high winds prevented crossing Bay Bastian to other sites.

71. On April 20, 1994, another reconnaissance trip was made to the experimental sites. A startling development was observed at Site 7. The gap in the island where the beach cones were placed had become a solid land mass along with the western part of the island that had disappeared during Hurricane Andrew. Apparently a storm (or perhaps several storms) had provided exactly the wave action required to transport material (mostly oyster shells) at an angle where vertical buildup could occur. It is suspected that the underwater dune caused by the beach cones caused waves to break at a critical point such that buildup could occur. Unfortunately, however, there is no way to prove that beach cones were responsible for this activity.

72. On May 5-6, and May 18-19, 1994, additional reconnaissance trips were made, primarily to Site 7. The rebuilt island appeared to be stable and no apparent changes has occurred since the April 20 visit.

73. On July 11, 1994, a reconnaissance trip was made to the experimental sites. Sites 7 was observed carefully. The changes observed originally on April 20, 1994, had stabilized and a renewed portion of Shell Island had become a reality.

74. On July 29, 1994, another reconnaissance trip was made to the experimental sites. Researchers from LSU obtained soil/water samples from all sites. Site 7 continued stable.

75. On August 12 - 13, August 27 - 28, September 4 - 5, and September 26, 1994, additional reconnaissance trips were made, primarily to Site 7. The rebuilt island continued to be stable and no apparent changes had occurred since the April 20 visit.

76. On October 10, 1994, a reconnaissance trip was made to the experimental sites. Sites 7 was visited and the changes observed originally on April 20, 1994, had not changed since the July - September observations.

77. On November 11, 1994, another reconnaissance trip was made to the experimental sites. Site 7 continued stable.

78. On December 14 - 15, 1994, an additional reconnaissance trip was made, primarily to Sites 2 and 7. Site 2 continues to build due to growth of oysters on the beach cones. At site 7, an apparent winter storm created a low area in the North-West end of the island. It was obvious that the materials washed away from this region were deposited just South and East of the low area, so the island had no net land loss. On this trip, researchers from Xavier University took soil samples from Sites 1, 2, and 7.

79. Reconnaissance trips were made to the sites on December 21 - 23, 1994, January 5 - 6, January 26, and February 10 -11, 1995. No significant changes in any of the sites were observed.

FINAL REPORT
BEACH CONE PROJECT
ASSESSMENT OF ECOLOGICAL QUALITY
XAVIER UNIVERSITY OF LOUISIANA

March 2, 1995

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INTRODUCTION

The purpose of this final report is to provide data on the quality of the sediments at various sites of the Beach Cone Study. In the statement of work, ecological assessment of sediments and biota were to be included. One approach toward ecological assessment is to study the biogeochemical cycle of trace metals. This report describes the comparative methods and results of an assessment of the trace metal content of the sediments and fish samples at the study site. We conclude by proposing questions which come out of the evaluation that require further research and study.

ANALYTICAL CAPABILITY

In order to evaluate trace metals it was necessary to upgrade the trace and ultra-trace element analysis capabilities. In 1994, Xavier upgraded the inorganic analytical capabilities and established a ***TRACE AND ULTRA-TRACE ELEMENT ANALYSIS LABORATORY.*** The upgrade has been possible as a result of funding through the cooperative interaction of several grants and has included all aspects of the instrumentation and the laboratory environment. The following technical features are present in the upgraded laboratory:

- The laboratory environment upgrade was undertaken with DOE funds to construct a ***Unilab Clean Room.*** The clean room was necessary because the laboratory is in a building constructed in the 1960's and is located within several hundred feet of a major freeway. Freeways are a major source of trace metals, especially lead and zinc. The clean room is 20 feet by 9 feet. It contains two ventilators equipped with HEPA filters that supply 100 particle air into the confines of the room. The clean room houses the analytical instruments.

- The Spectro® Inductively Coupled Plasma spectrometer (ICP) was upgraded with an ***Ultrasonic Nebulizer.*** This upgrade was purchased with grant money from ATSDR. The ultrasonic nebulizer increases the sensitivity of the ICP by a factor of 5 to 20 times depending on the element. For most elements, detection limit is in the low ppb range or better. The upgrade makes it possible to measure quantities of metals in minute samples of tissues.

- The DOE grant combined with funds from ATSDR made it possible to purchase a Perkin Elmer ***Atomic Absorption Spectrometer with a Graphite Furnace.*** This instrument has Zeeman background correction and has a sensitivity for most elements in the low ppt level. Some of the work being done by researchers at Xavier and Tulane requires much higher sensitivity than was possible with the ICP. This is due to the fact that the organisms being examined are very small (insect parts etc.) and dilution factors become magnified.

- Analytical capability was enhanced by the addition of two ***CEM ® microwave digestion systems*** purchased with funds from DOE. This equipment makes it possible to break down tissues using very small amounts of extraction solution and improves analytical sensitivity by reducing the dilution factor. It also makes it possible to prepare environmental samples with the EPA hot extraction methods.
- Finally, a Hamilton ***diluter/dispenser*** was added to the laboratory. This equipment was purchased with funds from ATSDR and provides improved accuracy in making up standards and controls for calibration and QA/QC protocols of our instruments.
- The laboratory takes part in the Analytical Products Group (APG) QA/QC performance evaluation program that is funded by the DOE. Our laboratory submits results of unknown samples on a monthly basis. Through this program laboratory analysis is certified and the laboratory meets stringent analytical standards that are required for funded projects.

SAMPLE COLLECTION

The samples were collected with a sediment coring tool. The sediments were cut into segments, placed into sample cups, covered and brought to the laboratory where they were stored in a refrigerator. The sediments were weighed, oven dried, reweighed, extracted, and analyzed using the standard protocol for soils. In the first survey, 18 sediment samples were collected from 7 sites. In the second survey 27 sediment samples were collected and analyzed from 4 sites, (Study sites 1, 2 and 7 plus a bayou location). In addition to core samples, fish samples (mainly minnows) were collected near site 7 using the traditional hook-line-bait capturing methods.

METHODS

Sediment Samples. There were two different methods of analysis used, a cold method developed for soils by Chaney and Mielke at the USDA in the mid-1970's, and a microwave method that is an EPA recognized method. All samples were extracted using the cold method. The cold method of extraction is done as follows: The extraction cup is labeled and the weight recorded. About 10 g of wet sample is added to the cup. The sediment samples are oven dried at 50 °C for 24 hours and reweighed. The sample dry weight minus cup weight is recorded. The samples are extracted using 25 ml of 1 M HNO_3. The sample plus extracting solution were shaken for 2 hours at room temperature. The extractant was filtered into vials for analysis and storage.

A selected group of three samples, differing with respect to texture and site of collection, were extracted with the hot method. The hot extraction method uses 0.5 g of dried sediment sample mixed with 10 ml concentrated (70%) trace metal grade HNO_3. A CEM

MDS 2000 (635 watts) microwave digester was used to remove organic matter and extract the metals from the samples. The extraction is done with a two stage program. Stage 1 use 100% power, 60 PSI, 50:00 minutes with 3:00 minutes (TAP). In stage 2, power is turned off for cool down. After cooling for an hour the extracts were poured into a polypropylene vial and brought up to 40ml with 18 mega Ω /cm deionized water.

Duplicate samples were included in the preparation of samples for both methods.

Fish Liver Samples.

The hot extraction method uses 1.7 g of wet fish liver sample mixed with 10 ml concentrated (70%) trace metal grade HNO_3. A CEM MDS 2000 (635 watts) microwave digester was used to remove organic matter and extract the metals from the samples. The extraction is done with a three stage program. Stage 1 use 70% power, 50 PSI, 10:00 minutes with 5:00 minutes (TAP). Stage 2 use 70% power, 100 PSI, 10:00 minutes with 5:00 minutes (TAP). Stage 3 use 70% power, 150 PSI, 10:00 minutes with 5:00 minutes (TAP). Then the power is turned off for cool down. After cooling for an hour the extracts were poured into a polypropylene vial and brought up to 40ml with 18 mega Ω /cm deionized water. The dry weights were calculated by multiplying 1.7g (wet weight)/.5g (estimated dry weight of 30% of wet weight) or 3.4.

All analysis was done with a Spectro® Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES). The liver samples were analyzed using an ultrasonic nebulizer.

RESULTS

Cold Extraction. The results of the cold extraction analysis of the sediment samples are given in Table 1.

The duplicate samples appear to be consistent throughout the run. Note that site 2 has the highest content of arsenic, cadmium, copper, lead, selenium and zinc. Site 2 is the location of a fishing camp. The lowest levels of metals occur in the beach sands of the gulf coast, site 7.

Cold Extraction Recovery. The results of the cold extraction recovery are given in Table 2.

Recovery for most samples generally range in the 70%+ level. A few samples had poor recovery, as low as 10.1 % for Gulf sand. Recovery was consistently in the high 70%'s for the bayou sediment and consistently low for gulf sand.

Hot Extraction Recovery. The results of the hot extraction recovery are given in Table 3.

Recovery for the hot extraction was generally higher than for the cold extraction method. The recoveries were consistently in the 70%'s and 80%'s for the silts and clays and lower for sands.

Table 1. DOE Beachcone Project. ICP-AES Analysis of Samples from Empire, LA Prepared by Cold Extraction Method.

Site	Name	Type	As	Cd	Cr*	Cu	Mn	Pb	Se	Zn 334 nm	Zn 213 nm
1	pseudocore 1	sediment	7.8	0.80	891.0	3.58	51.6	11.6	2.5	18.9	16.6
1	pseudocore 2	sediment	6.4	0.89	933.0	3.47	42.4	10.5	2.0	15.4	13.3
1	pseudocore 4	sediment	8.8	1.02	1108.0	5.05	50.8	14.7	2.9	22.9	21.3
1	pseudocore 5	sediment	6.1	0.89	851.0	3.53	45.8	11.0	2.1	16.2	12.1
1	pseudocore bottom	sediment	8.7	1.07	1206.0	7.18	52.6	14.7	2.9	22.1	20.1
1	scoop		2.3	0.93	490.0	0.53	137.9	11.5	2.3	38.1	4.9
1	scoop duplicate		2.8	0.89	474.0	0.54	136.9	11.7	2.2	32.4	6.8
2	murk 1		10.3	1.15	1654.0	12.27	50.7	24.1	3.4	154.2	144.6
2	murk 1duplicate		9.6	1.01	1643.0	11.75	47.0	20.4	3.2	120.7	114.5
2	murk 2		13.0	1.59	1953.0	13.85	63.9	22.5	4.2	162.5	154.3
2	murk 3		19.3	1.42	1623.0	18.41	125.8	93.9	7.3	102.4	98.0
2	murk next to bottom		19.4	1.45	1763.0	20.76	128.9	25.9	8.0	123.8	119.4
2	scoop near cones		10.0	1.35	1380.0	7.95	89.5	17.1	3.6	36.3	31.7
2	scoop near plants a		11.1	1.26	1431.0	13.23	216.1	32.9	5.4	187.9	171.4
2	scoop near plants b		20.1	1.73	1578.0	26.65	**nd**	51.0	9.4	391.8	342.8
7	gulf 1	sand	2.3	0.08	9.0	0.03	94.0	11.1	2.3	34.3	1.1
7	gulf 1 duplicate	sand	2.3	0.07	8.0	0.02	106.3	11.3	2.3	35.6	1.8
7	gulf 1 triplicate	sand	2.3	0.07	4.0	0.01	102.7	11.3	2.3	35.4	1.7
7	gulf 2	sand	2.3	0.07	3.0	nd	68.5	11.3	2.2	35.7	0.7
7	gulf 2 duplicate	sand	2.2	0.07	4.0	nd	64.4	11.1	2.1	35.3	0.6
7	middle	sand	2.5	0.07	8.0	0.01	64.8	11.3	2.3	34.7	0.7
7	river	sand	2.4	0.08	4.0	0.04	85.3	11.5	2.2	34.4	0.9
7	river duplicate	sand	2.2	0.07	5.0	0.05	58.6	11.1	2.2	33.7	0.6
Bayou	core 1	sediment	8.9	0.85	1340.0	4.97	61.7	12.9	3.5	22.1	19.9
Bayou	core 2	sediment	9.6	0.89	1430.0	5.20	61.7	13.2	3.6	24.8	23.4
Bayou	core 3	sediment	10.1	0.88	1447.0	4.85	**nd**	9.8	2.9	**nd**	20.5
Bayou	core 4	sediment	9.3	0.90	1439.0	6.00	45.2	14.2	3.4	23.0	21.7
Bayou	core 5	sediment	8.5	0.86	1308.0	5.51	56.6	13.5	3.2	21.5	20.1
Bayou	core 6	sediment	17.7	1.29	1801.0	10.84	131.1	18.8	9.1	28.6	26.5
Bayou	core 6 duplicate	sediment	18.2	1.50	2058.0	11.18	140.9	18.4	9.0	27.5	26.2
Bayou	core 7	sediment	13.6	1.37	1690.0	10.50	93.9	17.1	6.1	28.5	26.1
Bayou	core 8	sediment	9.9	0.97	1628.0	6.43	62.5	15.1	3.8	26.2	25.1
Bayou	core 9	sediment	8.2	0.90	1408.0	5.59	57.9	13.5	6.4	21.0	19.3
Bayou	core bottom	sediment	8.4	0.89	1344.0	4.63	45.0	12.1	3.2	20.7	18.5

Results are Shown in mcg / g dry weight. * Results in ng / g dry weight, nd: not determined.

Table 2. Recovery of a 20 mcg/mL Spike from DOE Beach Cone Project Samples Prepared by Cold Extraction Method, and Analyzed by ICP-AES.

Element/Sample	Spike + (μ g / g)	Spike - (μ g / g)	Net Spike (μ g / g)	% Recovered
Cd 226				
S7 Gulf (sand)	10.9	0.1	10.8	**54.5**
S2 Murk 1 (soil)	14.2	0.1	14.1	**70.9**
Bayou Core 6 (sediment)	15.0	0.2	14.7	**74.3**
Cu 324				
S7-Gulf (sand)	5.5	0.0	5.4	**27.4**
S2 Murk 1 (soil)	19.3	2.4	16.9	**85.1**
Bayou Core 6 (sediment)	17.6	2.2	15.5	**77.9**
Pb 220				
S7 Gulf (sand)	4.3	2.3	2.0	**10.1**
S2 Murk 1 (soil)	19.5	4.4	15.1	**76.0**
Bayou Core 6 (sediment)	19.0	3.4	15.6	**78.7**
Zn 213				
S7 Gulf (sand)	13.7	0.3	13.4	**67.5**
S2 Murk 1 (soil)	35.8	25.9	9.9	**49.8**
Bayou Core 6 (sediment)	20.2	5.2	15.0	**75.6**
Zn 334				
S7 Gulf (sand)	21.3	7.1	14.2	**71.6**
S2 Murk 1 (soil)	38.4	27.5	10.9	**55.1**
Bayou Core 6 (sediment)	21.2	5.6	15.6	**78.7**

Table 3. Recovery of a 3 mcg/ml Spike from DOE Beach Cone Project Samples Prepared by Hot Extraction Method and Analized by ICP-AES .

Element/Sample	Spike + (μ g / g)	Spike - (μ g / g)	Net Spike (μ g / g)	% Recovered
Cd 226				
S7 Gulf (sand)	2.36	0.06	2.30	**73.8**
S2 Murk 1 (soil)	2.74	0.04	2.70	**86.6**
Bayou Core 6 (sediment)	2.81	0.04	2.77	**88.7**
Cu 324				
S7 Gulf (sand)	2.53	0.00	2.53	**80.9**
S2 Murk 1 (soil)	3.42	0.53	2.89	**92.7**
Bayou Core 6 (sediment)	3.04	0.17	2.87	**92.1**
Pb 220				
S7 Gulf (sand)	3.82	1.63	2.19	**70.2**
S2 Murk 1 (soil)	3.56	0.80	2.76	**88.6**
Bayou Core 6 (sediment)	3.33	0.46	2.86	**91.8**
Zn 213				
S7 Gulf (sand)	2.22	0.12	2.11	**67.5**
S2 Murk 1 (soil)	4.63	2.37	2.25	**72.2**
Bayou Core 6 (sediment)	3.01	0.64	2.37	**75.8**
Zn 334				
S7 Gulf (sand)	3.10	1.07	2.03	**65.0**
S2 Murk 1 (soil)	4.55	1.91	2.64	**84.6**
Bayou Core 6 (sediment)	2.65	0.00	2.65	**84.9**

Table 4. ICP-AES of Duplicate DOE Beachcone Project Samples Prepared by Cold(c) and Hot(h) Extraction Methods.

								μ g/g								
Sample	**As(c)**	**As(h)**	**Cd(c)**	**Cd(h)**	**Co(c)**	**Co(h)**	**Cr(c)**	**Cr(h)**	**Cu(c)**	**Cu(h)**	**Pb(c)**	**Pb(h)**	**Se(c)**	**Se(h)**	**Zn(c)**	**Zn(h)**
Site 7 Gulf	2.22	11.68	0.37	0.96	0.81	2.08	0.13	0.56	0.10	7.52	1.08	24.96	2.17	4.72	0.57	5.60
Site 7 Gulf Dup.	2.15	10.16	0.36	0.80	0.76	1.84	0.12	0.40	0.11	4.08	1.06	21.36	2.04	3.84	0.47	4.88
Site 2 Murk 1	9.45	58.08	0.65	1.60	1.27	4.24	1.21	8.96	12.95	48.00	19.96	41.92	2.46	14.40	186.28	194.88
Site 2 Murk 1 Dup.	9.33	44.08	0.51	1.20	1.17	3.36	1.20	7.12	12.36	37.68	16.43	30.24	2.46	9.92	138.08	172.08
Bayou Core 6	19.07	53.52	0.78	1.44	2.35	4.40	1.36	7.92	10.16	7.60	12.80	24.16	6.18	14.64	22.83	40.56
Bayou Core 6 Dup.	20.47	48.80	0.88	1.36	2.47	4.48	1.51	7.20	10.83	5.92	14.05	24.00	6.67	14.16	23.63	41.04

Table 5. DOE Beachcone Project. ICP-AES Analysis of Liver Samples from Fish Caught at Empire, LA.

Liver	Element in μ g / g wet wt Cd	Co	Cr	Cu	Pb	Se	Zn
1	0.16	0.38	0.12	11.66	1.12	1.82	24.03
2	0.11	0.54	0.12	11.64	0.92	1.50	64.81
3	0.10	0.38	0.06	ndt	0.46	1.22	43.41
4	0.06	0.24	ndt	3.44	ndt	0.39	18.57
5	0.10	0.39	0.04	9.20	0.43	0.98	39.25
6	0.08	0.29	0.02	11.17	0.35	1.27	37.79
7	0.13	0.26	ndt	12.56	ndt	0.58	31.89
8	0.05	0.26	ndt	6.40	0.05	0.70	21.77
9	0.03	0.24	ndt	8.36	ndt	0.26	30.09

Liver	Element in μ g / g dry wt Cd	Co	Cr	Cu	Pb	Se	Zn
1	0.5	1.3	0.4	39.7	3.8	6.2	81.7
2	0.4	1.8	0.4	39.6	3.1	5.1	220.3
3	0.4	1.3	0.2	ndt	1.6	4.1	147.6
4	0.2	0.8	ndt	11.7	ndt	1.3	63.2
5	0.3	1.3	0.1	31.3	1.5	3.3	133.5
6	0.3	1.0	0.1	38.0	1.2	4.3	128.5
7	0.4	0.9	ndt	42.7	ndt	2.0	108.4
8	0.2	0.9	ndt	21.8	0.2	2.4	74.0
9	0.1	0.8	ndt	28.4	ndt	0.9	102.3

Samples Were Digested in CEM MDS 2000. ndt: not detected

FIELD STUDY OF BEACH CONES

FINAL REPORT

SUBCONTRACT FROM TULANE UNIVERSITY

UNDER DOE C.A. # DE-AC22-92MT92002

submitted by

R.D. DeLaune and C.W. Lindau

Wetland Biogeochemistry Institute

Center for Coastal, Energy and Environmental Resources

Louisiana State University

Baton Rouge, LA 70803

March 1995

SITE CHARACTERIZATION

The first year effort was directed at providing background data on chemical and physical characteristics of sediment prior to cone placement. Sediment (cores and surface) and plant materials collected near cone sites located in Plaqumine Parish, Louisiana were characterized for elemental content and sedimentation rates. The samples were collected several weeks prior to cone placement.

Ten cm diameter cores taken from selected sites in Spring of 92 were sectioned into 3 cm increment, dried and ^{137}Cs activity quantified using a Germanium detector and multi-channel analysis profile distribution of ^{137}Cs and used to estimate sedimentation rates (DeLaune et al., 1978). Surface sediment was collected with the aid of a Peterson dodge. Vegetation samples were collected randomly from marsh sites in vicinity of the sites in which the cone were subsequently installed. Total element content in surface sediment and in marsh vegetation near the cone displace site were determined by acid digested and ICP analysis (Plumb, 1981).

Results from ^{137}Cs profiled distribution indicated rapid rates of sedimentation at the two marsh sites sampled (Fig. 1a & 1b). At site 2, the rate was greater than 1 cm/year. This actual sedimentation rate could not be calculated because the 63 horizon (years of maximum ^{137}Cs fall-out) was not reached. The marsh at site 3 (which the 63 marsh horizon was evident) indicated a sedimentation rate of 1.3 cm/year. The sedimentation rates obtained from the 2 cores would not compensate for reported subsidence or submergence rates reported for this area of the Mississippi River deltaic plain. Compared to submergence, the sedimentation rate support the rapid rate of marsh deterioration in this particular area of coastal Louisiana.

Sedimentation rate was difficult to determine in the core collected from the bay-bottom (Figs. 1a - 1f). The sediment physical characteristics (sand and shell fragment) at sites 2, 3, and 6 did not retain sufficient ^{137}Cs to estimate sedimentation rates. Site 5 was the only core in which we are able to obtain an adequate ^{137}Cs profile distribution. Using the 63 marker we estimate sedimentation to be approximately 0.70 cm/year at site 5, a rate also considerably less than subsidence in the area.

Elemental content of plant tissue were determined at five marsh sites (Table 1). These concentrations will be compared to the elemental contents of tissue of any marsh vegetation colonizing each site if sufficient sediment is trapped by the cones to support vegetation.

Elemental content of bottom sediment of the sites (3 location at each site) was characteristic for the sediments in the area (Table 2). The chemical and physical properties of the sediment retained by the cones will be compared to these baseline sediment analysis. The collected sediment are currently being analyzed for particle size distribution (sand, salt, and clay) which will be compared to distribution of sediment trapped by the cones.

The sediment data collected at the sites prior to placement of the cones provide the baseline information on plant-sediment on each site which will be used to compare sediment-vegetation relationships on these sites as affected by cone placement. The potential changes in sediment characteristics and vegetation structural/compositional changes were further evaluated in a follow-up sampling.

On June 29, 1994 a follow-up evaluations of sediment trapped was conducted. Sediment was collected from the cores which had trapped sediment. The sediment material was acid digested and analyzed for total element content. The chemical characteristics of the trapped material was found to be similar to the sediment collected from the sites previous to cone placement. The only difference was the greater amount of shell fragment as depicted by the calcium in manganese content of the sediment (Table 3).

There was no vegetation within or near the cone structure. Accordingly we were not able to evaluate recruitment of vegetation at the site which the cones were placed.

In summary it was apparent that the cones were to a degree able to trap sediment. There however was not enough sediment trapped over the time frame of the investigation to allow for marsh vegetation establishment. Further long-term evaluation of cone placement, sediment trappment and plant recruitment is warranted. The mineral or nutrient content of the sediment would support growth of vegetation if sufficient sediment was trapped to increase the elevation to the mean tidal range suitable for supporting growth of marsh plants.

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Plumb, R.H., Jr. 1981. Procedures for handling chemical analysis of sediment and water samples. Technical Report EPA/CE-81-1. Environmental Laboratory, U.S. Army Waterways Experiment Station, Vicksburg, Mississippi.

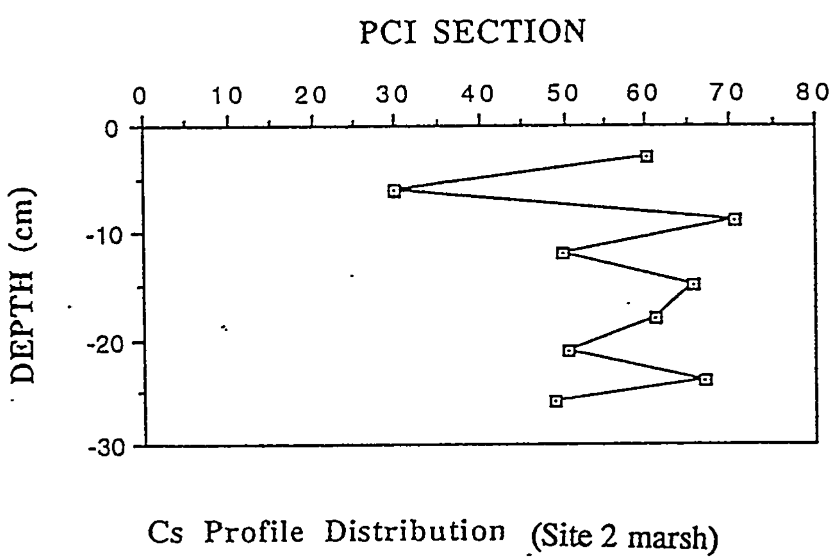


Fig. 1a. ^{137}Cs profile distribution at site 2 (marsh)

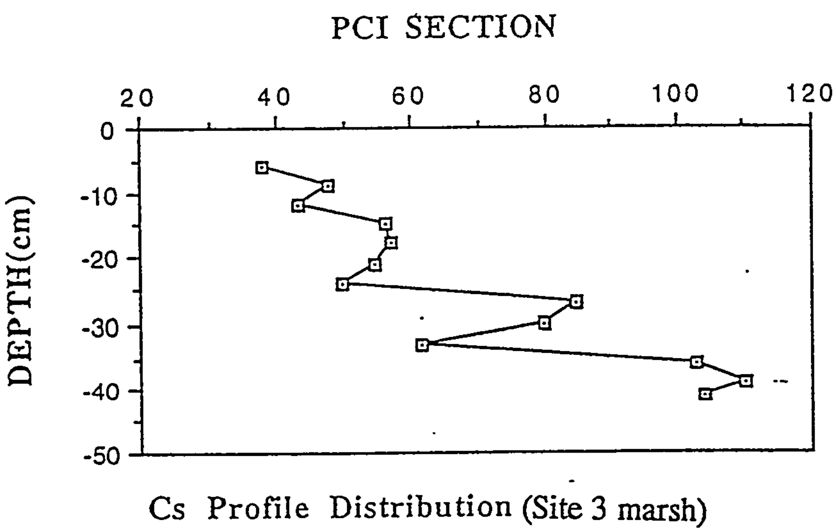


Fig. 1b. ^{137}Cs profile distribution at site 3 (marsh)

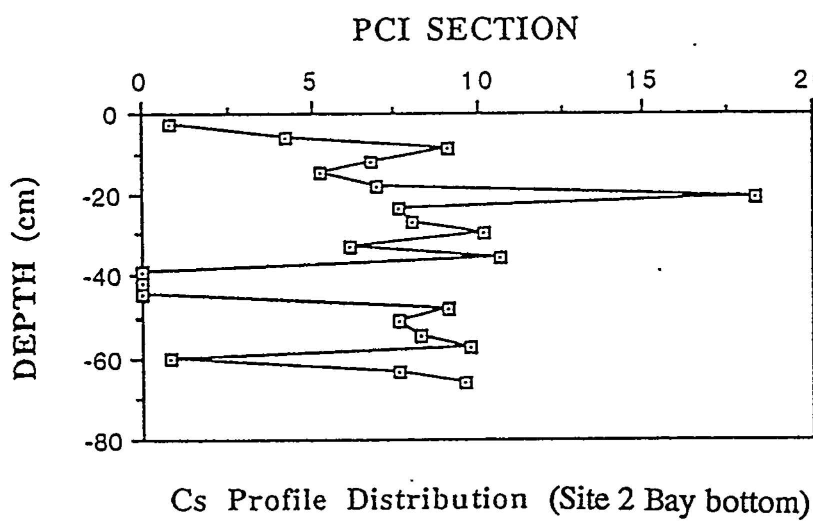


Fig. 1c. ^{137}Cs profile distribution at site 2 (Bay bottom)

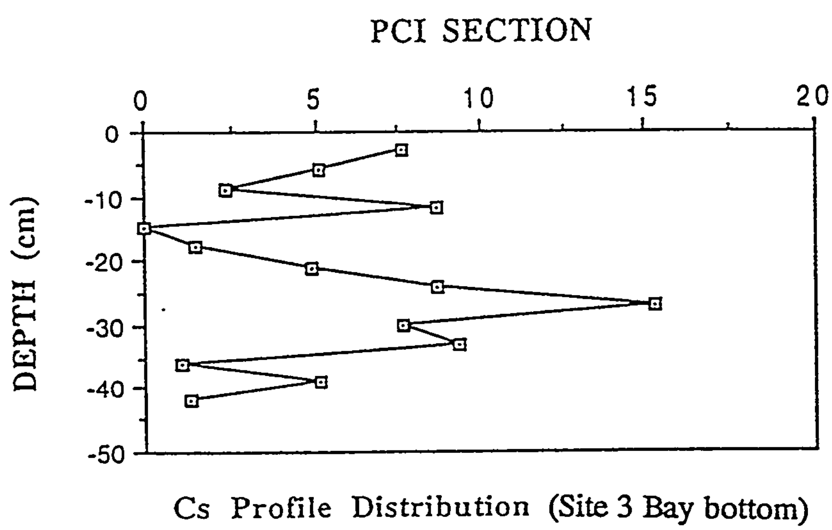


Fig. 1d. ^{137}Cs profile distribution at site 3 (Bay bottom)

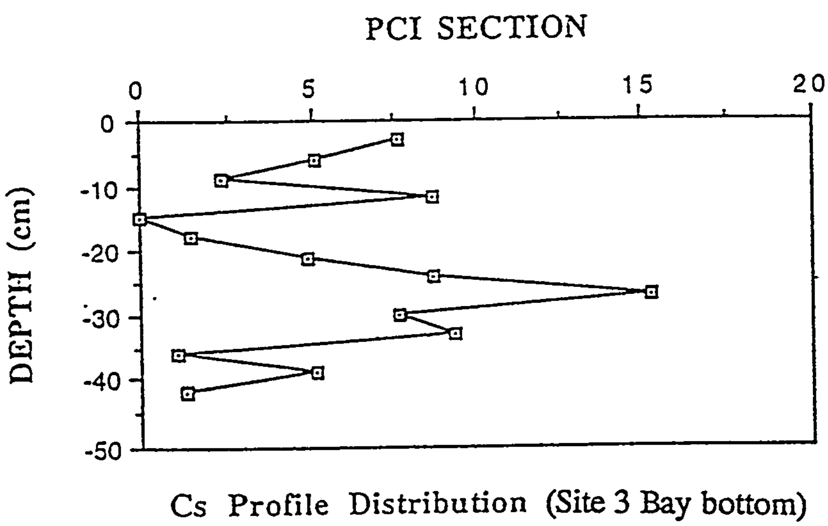


Fig. 1d. ^{137}Cs profile distribution at site 3 (Bay bottom)

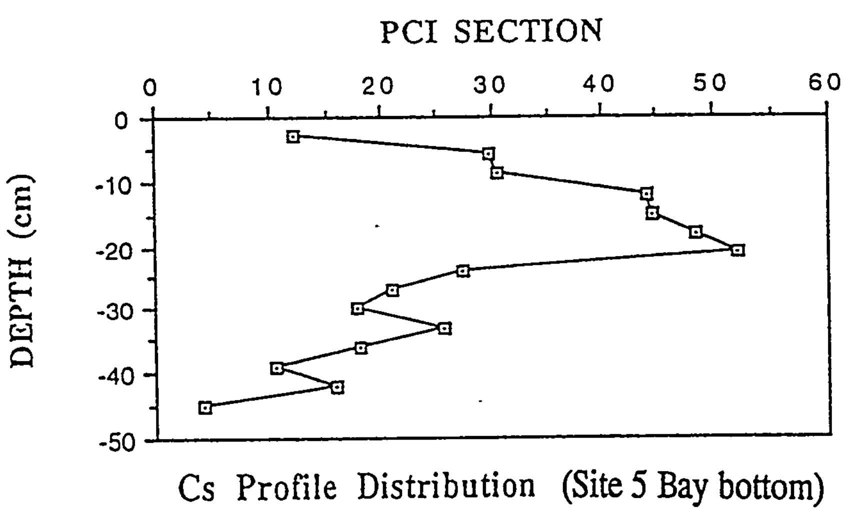


Fig. 1e. ^{137}Cs profile distribution at site 5 (Bay bottom)

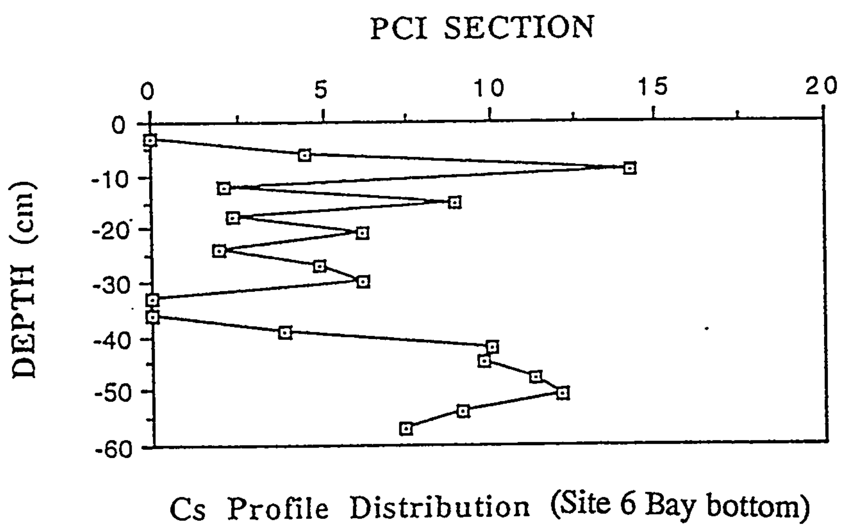


Fig. 1f. ^{137}Cs profile distribution at site 6 (Bay bottom)

(Site 3 marsh)

	depth	dry wt.	area	pci section
1	-3.000	207.539		
2	-6.000	179.400	179.000	38.030
3	-9.000	187.600	225.000	47.803
4	-12.000	188.300	203.000	43.129
5	-15.000	226.300	264.000	56.089
6	-18.000	213.700	268.000	56.939
7	-21.000	233.400	256.000	54.390
8	-24.000	195.100	233.000	49.503
9	-27.000	239.400	399.000	84.772
0	-30.000	223.900	375.000	79.673
1	-33.000	208.700	290.000	61.613
2	-36.000	219.500	484.000	102.831
3	-39.000	368.800	518.000	110.054
4	-41.000	112.000	490.000	104.105

(Site 3 marsh)

	depth	dry wt.	area	pci section
1	-3.000	207.539		
2	-6.000	179.400	179.000	38.030
3	-9.000	187.600	225.000	47.803
4	-12.000	188.300	203.000	43.129
5	-15.000	226.300	264.000	56.089
6	-18.000	213.700	268.000	56.939
7	-21.000	233.400	256.000	54.390
8	-24.000	195.100	233.000	49.503
9	-27.000	239.400	399.000	84.772
0	-30.000	223.900	375.000	79.673
1	-33.000	208.700	290.000	61.613
2	-36.000	219.500	484.000	102.831
3	-39.000	368.800	518.000	110.054
4	-41.000	112.000	490.000	104.105

(Site 2 Bay bottom)

	depth	dry wt.	area	pci section
1	-3.000	191.048	4.000	0.850
2	-6.000	118.661	20.000	4.249
3	-9.000	124.201	43.000	9.136
4	-12.000	106.218	32.000	6.799
5	-15.000	130.229	25.000	5.311
6	-18.000	124.934	33.000	7.011
7	-21.000	102.905	86.000	18.272
8	-24.000	85.803	36.000	7.649
9	-27.000		38.000	8.073
10	-30.000		48.000	10.198
11	-33.000	76.098	29.000	6.161
12	-36.000	119.930	50.000	10.623
13	-39.000	110.618	0.000	0.000
14	-42.000	163.144	0.000	0.000
15	-45.000	147.593	0.000	0.000
16	-48.000	145.349	43.000	9.136
17	-51.000	171.403	36.000	7.649
18	-54.000	80.869	39.000	8.286
19	-57.000	83.068	46.000	9.773
20	-60.000	120.020	4.000	0.850
21	-63.000	127.630	36.000	7.649
22	-66.000	121.290	45.000	9.561

(Site 3 Bay bottom)

	depth	dry wt.	area	pci section
1	-3.000	202.320	36.000	7.649
2	-6.000	170.456	24.000	5.099
3	-9.000	136.174	11.000	2.337
4	-12.000	163.187	41.000	8.711
5	-15.000	222.078	0.000	0.000
6	-18.000	152.422	7.000	1.487
7	-21.000	106.368	23.000	4.887
8	-24.000	145.746	41.000	8.711
9	-27.000	208.107	72.000	15.297
10	-30.000	202.810	36.000	7.649
11	-33.000	179.637	44.000	9.348
12	-36.000	183.658	5.000	1.062
13	-39.000	152.288	24.000	5.099
14	-42.000	226.491	6.000	1.275

(Site 6 Bay bottom)

	depth	dry wt.	area	pci section
1	-3.000	78.637	57.000	12.110
2	-6.000	160.747	140.000	29.744
3	-9.000	152.570	143.000	30.382
4	-12.000	290.701	208.000	44.192
5	-15.000	191.131	210.000	44.617
6	-18.000	198.349	228.000	48.441
7	-21.000	407.724	246.000	52.265
8	-24.000	519.532	129.000	27.407
9	-27.000	563.099	99.000	21.034
10	-30.000	491.327	84.000	17.847
11	-33.000	640.002	120.000	25.495
12	-36.000	508.337	85.000	18.059
13	-39.000	685.698	49.000	10.411
14	-42.000	616.404	75.000	15.934
15	-45.000	719.853	19.000	4.037

(Site 5 Bay bottom)

	depth	dry wt.	area	pci section
1	-3.000	101.783	0.000	0.000
2	-6.000	111.549	21.000	4.462
3	-9.000	106.154	67.000	14.235
4	-12.000	76.152	10.000	2.125
5	-15.000	111.597	42.000	8.923
6	-18.000	91.603	11.000	2.337
7	-21.000	100.067	29.000	6.161
8	-24.000	103.314	9.000	1.912
9	-27.000	70.688	23.000	4.887
10	-30.000	120.263	29.000	6.161
11	-33.000	216.880	0.000	0.000
12	-36.000	272.820	0.000	0.000
13	-39.000	132.938	18.000	3.824
14	-42.000	157.563	47.000	9.986
15	-45.000	174.291	46.000	9.773
16	-48.000	220.022	53.000	11.260
17	-51.000	197.888	57.000	12.110
18	-54.000	101.952	43.000	9.136
19	-57.000	66.084	35.000	7.436

DEPARTMENT OF NATURAL RESOURCES
COASTAL MANAGEMENT DIVISION
P. O. BOX 44487
BATON ROUGE, LOUISIANA 70804-4487
(504) 342-7591

D23

COASTAL USE PERMIT/CONSISTENCY DETERMINATION

C.U.P. No. P920100

C.O.E. No. NOD-22

NAME AND ADDRESS: DR. VICTOR LAW, Ph.D.: Attn: Bud Brodtmann, c/o EPL, Inc., 4813 W. Napoleon Ave., Metairie, LA 70001

LOCATION: SEE NEXT PAGE

PROJECT DESCRIPTION: SEE NEXT PAGE

In accordance with the rules and regulations of the Louisiana Coastal Resources Program and Louisiana R.S. 49, Sections 213.1 to 213.21, the State and Local Coastal Resources Management Act of 1978, as amended, the permittee agrees to:

1. Carry out or perform the use in accordance with the plans and specifications approved by Department of Natural Resources.
2. Comply with any permit conditions imposed by the Department of Natural Resources.
3. Adjust, alter, or remove any structure or other physical evidence of the permitted use if, in the opinion of the Department of Natural Resources, it proves to be beyond the scope of the use as approved or is abandoned.
4. Provide, if required by the Department of Natural Resources, an acceptable surety bond in an appropriate amount to ensure adjustment, alteration, or removal should the Department of Natural Resources determine it necessary.
5. Hold and save the State of Louisiana, the local government, the department, and their officers and employees harmless from any damage to persons or property which might result from the use, including the work, activity, or structure permitted.
6. Certify that the use has been completed in an acceptable and satisfactory manner and in accordance with the plans and specifications approved by the Department of Natural Resources. The Department of Natural Resources may, when appropriate, require such certification be given by a registered professional engineer.
7. All terms of the permit shall be subject to all applicable federal and state laws and regulations.
8. This permit, or a copy thereof, shall be available for inspection at the site of work at all times during operations.
9. The applicant will notify the Coastal Management Division of the date on which initiation of the permitted activity described under the "Coastal Use Description" began. The applicant shall notify the Coastal Management Division by mailing the enclosed green initiation card on the date of initiation of the coastal use.
10. Unless specified elsewhere in this permit, this permit authorizes the initiation of the coastal use described under "Coastal Use Description" for two years from the date of the signature of the Secretary or his designee. If the coastal use is not initiated within this two year period, then this permit will expire and the applicant will be required to submit a new application. Initiation of the coastal use, for purposes of this permit, means the actual physical beginning of the use or activity for which the permit is required. Initation does not include preparatory activities, such as movement of equipment onto the coastal use site, expenditure of funds, contracting out of work, or performing activities which by themselves do not require a permit. In addition, the permittee must, in good faith and with due diligence, reasonably progress toward completion of the project once the coastal use has been initiated.
11. This Coastal Use Permit authorizes periodic maintenance, but such maintenance activities must be conducted pursuant to the specifications and conditions of this permit.
12. The following special conditions must also be met in order for the use to meet the guidelines of the Coastal Resources Program:

C.U.P. No. P920100

C.O.E. No. NOD-22

LOCATION: **PLAQUEMINES PARISH, LA:** Sec. 41, T20S-R28E, northeast shoreline of Halfmoon Bay between Lat. 29°21'28"N, Long. 89°37'48"W and Lat. 29°21'14"W, Long. 89°37'44"W (Site No. 1); Secs. 4, 5, 8, and 9, T21S-R28E, east bankline of Bayou Cook between Lat. 29°20'00"N, Long. 89°38'28"W and Lat. 29°19'45"W, Long. 89°38'32"W (Site No. 2), and north shoreline of Bastian Bay between Lat. 29°19'45"N, Long. 89°38'42"W and Lat. 29°19'34"W, Long. 89°38'20"W (Site No. 3); Secs. 7 and 8, T21S-R21E, west shoreline of Bastian Bay at Lat. 29°19'19"N, Long. 89°39'34"W (Site No. 4), and between Lat. 29°18'34"N, Long. 89°40'05"W and Lat. 29°18'33"W, Long. 89°40'05"W (Site No. 5); Sec. 21, T21S-R28E, north shoreline of Shell Island Bay between Lat. 29°17'14"N, Long. 89°38'30"W and Lat. 29°17'22"W, Long. 89°37'50"W (Site No. 6); and Secs. 19, 20, 28, 29, 33, 34, and 35, T21S-R28E, south (Gulf of Mexico) shoreline of remnants of Lanaux Island (Shell Island) between Lat. 29°17'16"N, Long. 89°40'12"W and Lat. 29°15'15"N, Long. 89°36'30"W (Site No. 7); approx. 6 mi. southwest of Empire, LA, oyster lease area.

PROJECT DESCRIPTION:
Proposal to install glass fiber-reinforced concrete "beach cone" erosion control modules along different types of shorelines at seven study sites in the vicinity of Bastian Bay. The objectives of the proposed study are to determine the effectiveness of the "beach cone" erosion control modules in providing protection from shoreline erosion and inducing the accretion of water-borne sediments to rebuild shorelines, as well as to assess their effect on adjacent shorelines, and to define the hydrodynamics of the modules by in-the-field monitoring. All study sites will be located in shallow water between 2.0 ft. and 3.0 ft. MSL. All study sites will be approx. 15 ft. wide and have the following approx. lengths: Site No. 1, 1500 ft.; Site No. 2, 2500 ft.; Site No. 3, 2500 ft.; Site No. 4, 500 ft.; Site No. 5, 600 ft.; Site No. 6, 5000 ft.; and Site No. 7, 27000 ft. Spacing of the "beach cone" erosion control modules within Site Nos. 1 through 6 will be no less than 100 ft. apart, and within Site No. 7 the spacing will be no less than 1000 ft. apart. Precise locations for deployment of the modules within each of the study areas will be determined on the basis of field surveys, including soil borings and identification of water bottom conditions. Each array of modules will be marked with 2 in. diameter white PVC pipe fitted with reflective tape and an 11 in. x 17 in. reflective sign to identify their locations and to alert boaters of their presence. Monitoring and evaluation of the study sites shall be conducted frequently for a period of at least two years after deployment to evaluate the effectiveness of the modules at the points of deployment and on adjoining and/or adjacent shorelines, and the effectiveness of differing orientations and/or geometric patterns of placement of the modules at the study sites. Any modules found to be ineffective or to be exacerbating shoreline erosion at any study site and/or adjoining shorelines will be promptly removed and properly disposed of. There are oyster leases in the vicinity of the proposed work.

a. That the applicant shall insure that all sanitary sewage and/or related domestic wastes generated during the subject project activity and at the site, thereafter, as may become necessary shall receive the equivalent of secondary treatment (30 mg/l BOD_5; 30 mg/l TSS) with disinfection prior to discharge into any of the streams or adjacent waters of the area or, in the case of total containment, shall be disposed of in approved sewerage and sewage treatment facilities, as is required by the State Sanitary Code. Such opinion as may be served by those comments offered herein shall not be construed to suffice as any more formal approval(s) which may be required of possible sanitary details (i.e. provisions) scheduled to be associated with the subject activity. Such shall generally require that appropriate plans and specifications be submitted to the Department of Health and Hospitals for purpose of review and approval prior to any utilization of such provisions.

b. Shorelines that become increasingly eroded as a result of deployment of these beach cone modules shall be stabilized by methods other than bulkheading (i.e. rip-rap, matting material, or natural vegetation). This condition does not preclude the necessity of obtaining a separate Coastal Use Permit, should one be required, for such shoreline stabilization activities.

c. Applicant shall remove and promptly dispose of any modules found to be ineffective or to be exacerbating shoreline erosion at any study site and/or on adjoining shorelines.

d. That a permit is received from the Division of State Lands prior to the initiation of construction and that a lease is obtained from the State Land Office at the completion of construction.

e. All beach cone modules and study site markers shall be removed within 120 days of abandonment of the facilities for the herein permitted use unless prior written approval to leave such structures in place is received from the Coastal Management Division. This condition does not preclude the necessity for revising the current permit or obtaining a separate Coastal Use Permit, should one be required, for such removal activities.

f. The following provisions are required by the Louisiana Department of Wildlife and Fisheries (LDWF) to protect the oyster resources of Bastian Bay. Dr. Victor Law, Ph.D. shall adhere to these provisions:

1) The permittee shall provide notification of the proposed activity to any oyster lease holder who may be affected by it prior to commencement of the activity. Copies of notification letters sent to the oyster lease holder(s) shall be provided to the Coastal Management Division prior to commencement of the activity.

2) Applicant is subject to all applicable state laws related to damages which are demonstrated to have been caused by this action.

3) Applicant shall make every possible effort to avoid crossing current oyster leases.

4) Applicant shall, to the maximum extent possible, avoid crossing both living and non-living reefs on state owned water bottoms when choosing a route to and from the proposed locations.

g. (i) This permit authorizes the initiation of the Coastal Use described under "Coastal Use Description" for two years from the date of the signature of the Secretary or his designee. Initiation of the Coastal Use, for purposes of this permit, means the actual physical beginning of the use or activity for which the permit is required. Initiation does not include preparatory activities, such as movement of equipment onto the Coastal Use site, expenditure of funds, contracting out of work, or performing activities which by themselves do not require a permit. In addition, the permittee must, in good faith and with due diligence, reasonably progress toward completion of the project once the Coastal Use has been initiated. If the Coastal Use is not initiated within this two year period, an extension may be granted pursuant to the requirements contained in the Rules and Procedures for Coastal Use Permits (Title 43:I.723.D.). Please note that a request for permit extension MUST be made no sooner than 180 days and no later than 60 days prior to the expiration of the permit.

(ii) The expiration date of this permit is five (5) years from the date of the signature of the Secretary or his designee.

(iii) Upon expiration of this permit, a new Coastal Use Permit will be required for completion of any unfinished or uncommenced work items and for any maintenance activities involving dredging or fill that may become necessary. Other types of maintenance activities may also require a new Coastal Use Permit.

h. The permittee shall allow representatives of the Coastal Management Division or authorized agents to make periodic, unannounced inspections to assure the activity being performed is in accordance with the conditions of this permit.

i. In order to ensure the safety of all parties, the permittee shall contact the Louisiana DOTTIE System (1-800-272-3020) a minimum of 48 hours prior to the commencement of any excavation (digging, dredging, jetting, etc.) or demolition activity.

j. It is requested that the applicant provide a copy of any progress and final reports on this study effort, as well as a reprint of any scientific paper published on the study, to Mr. Rocky Hinds, Department of Natural Resources, Coastal Management Division, P.O. Box 44487, Baton Rouge, LA 70804-4487 and Mr. Fred Dunham, Department of Wildlife and Fisheries, Ecological Studies, P.O. Box 98000, Baton Rouge, LA 70898-9800.

By accepting this permit the applicant agrees to its terms and conditions.

I affix my signature and issue this permit this 9th day of June, 19 92.

DEPARTMENT OF NATURAL RESOURCES

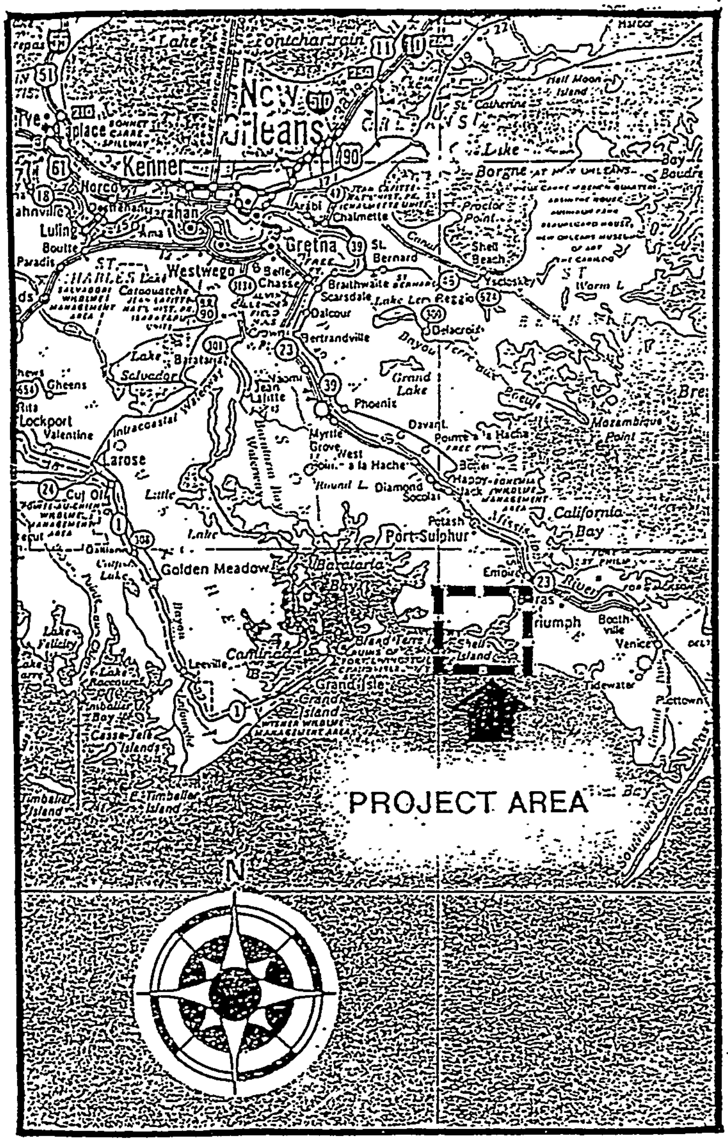
Terry W. Howey

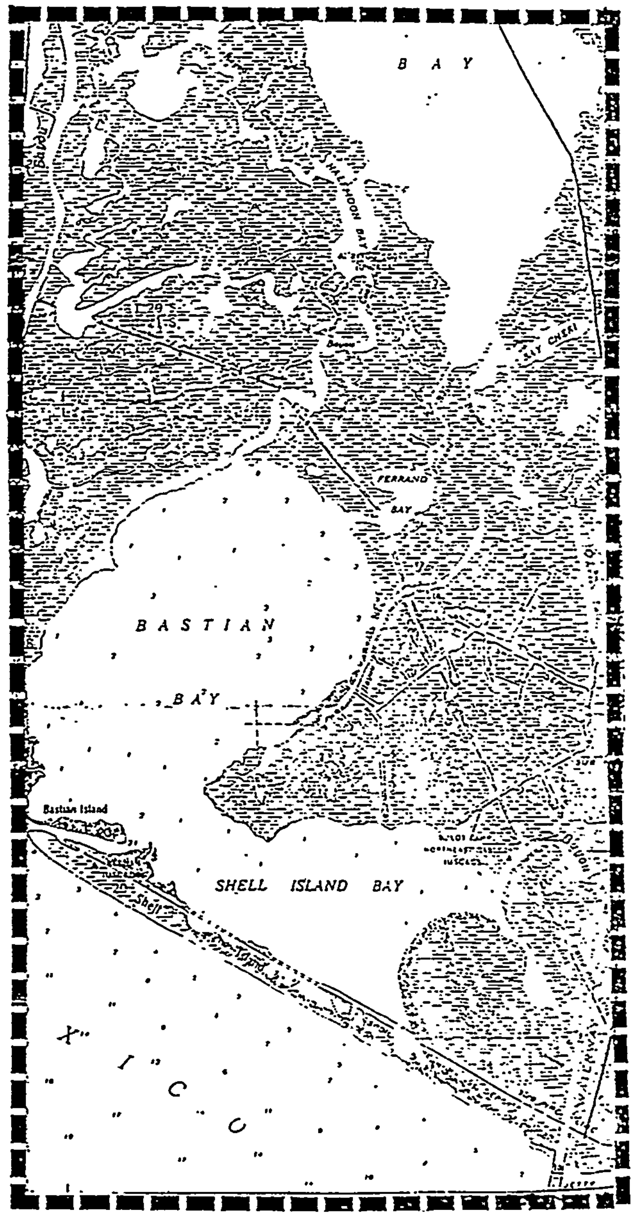
TERRY W. HOWEY, DIRECTOR
Coastal Management Division

This agreement becomes binding when signed by the Director of the Coastal Management Division, Department of Natural Resources.

Final Plats
P920100
1 June 1992
KAV

VICINITY MAP





PROJECT AREA ENLARGED

ENVIRONMENTAL PROFESSIONALS LTD 4813 W. NAPOLEON AVENUE METAIRIE, LOUISIANA 70001	
Scale: NONE	Date: 1/27/91
Drawn By: AMP	Approved By: NRB

Final Plats
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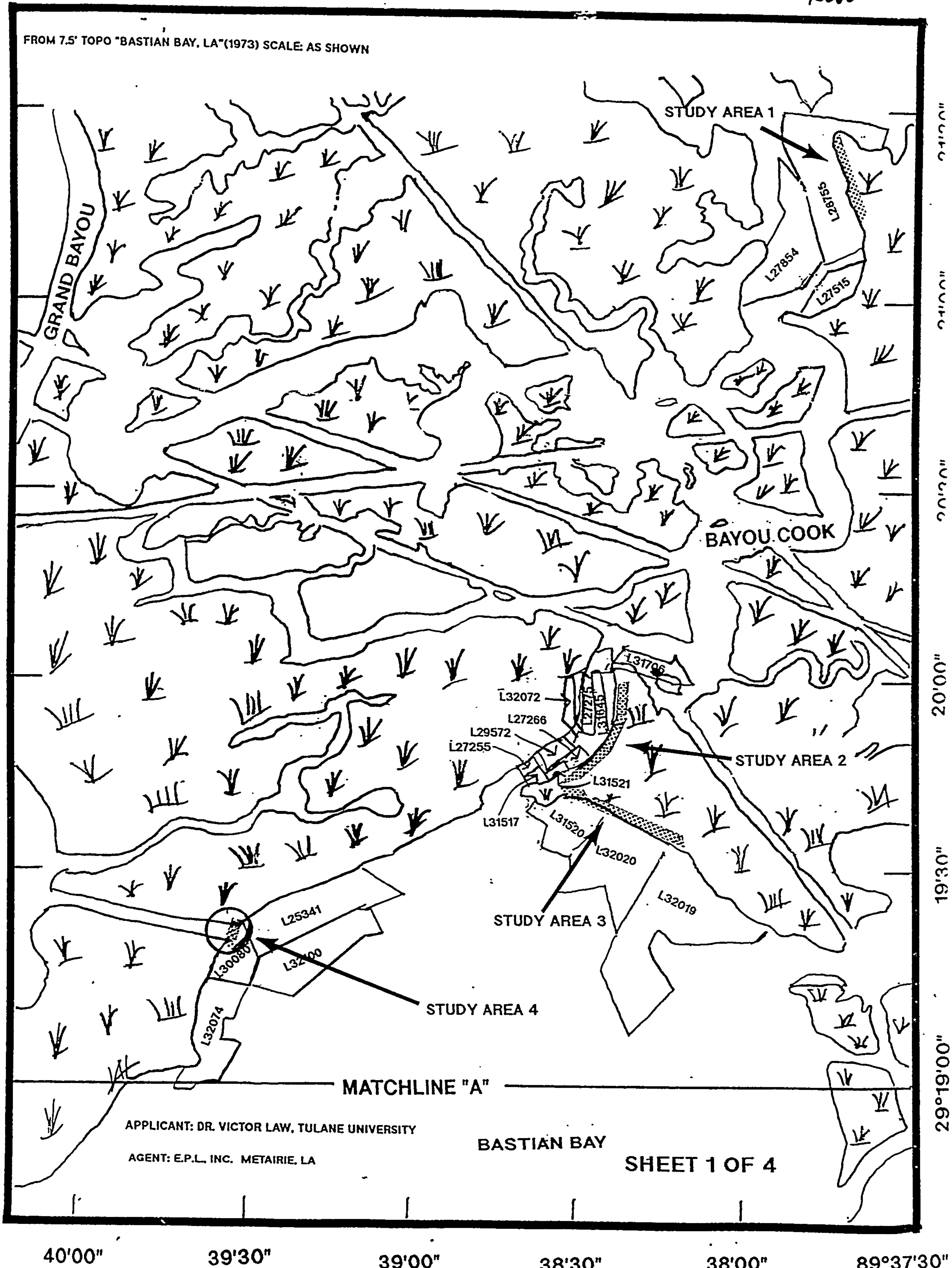
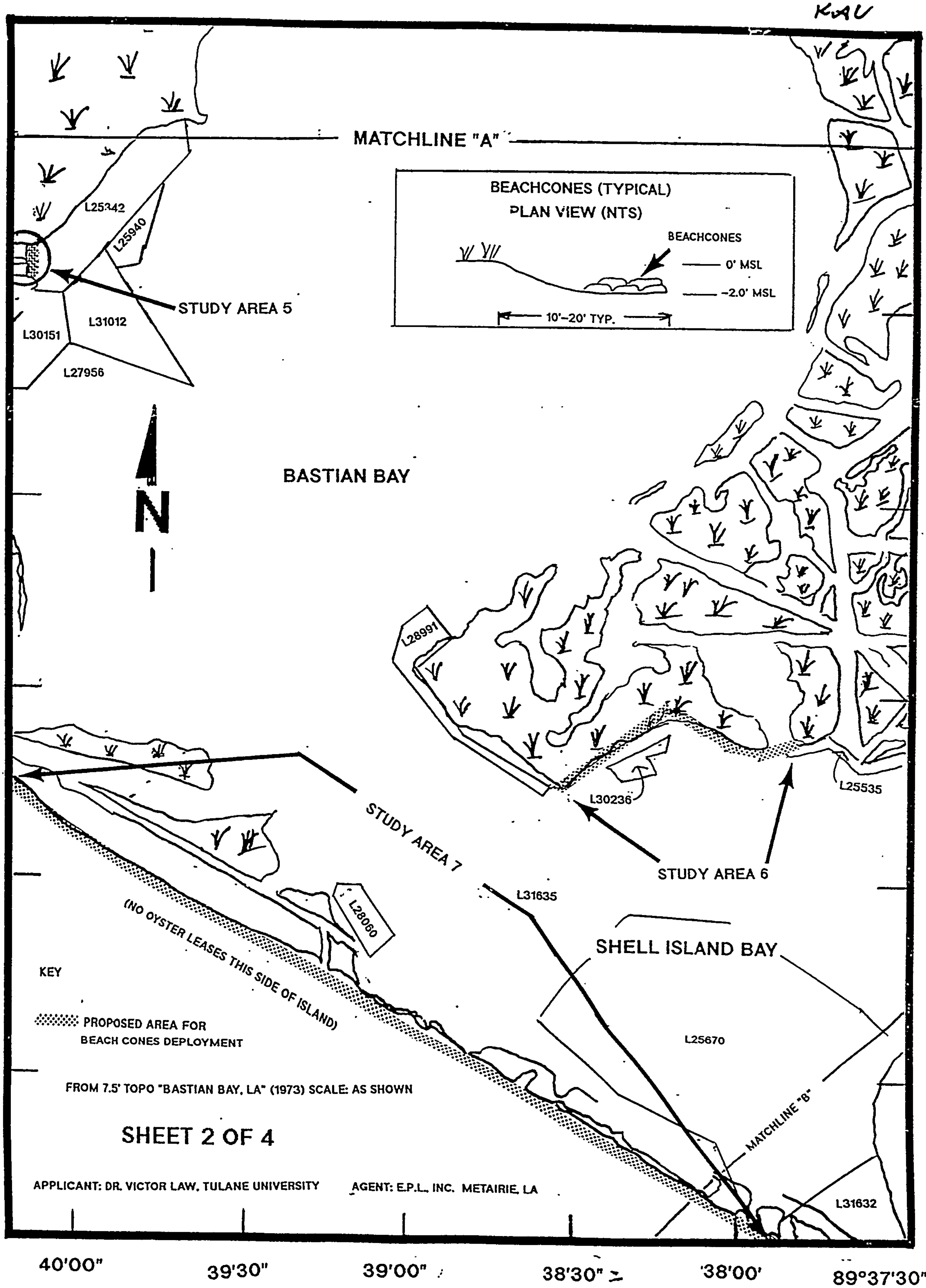
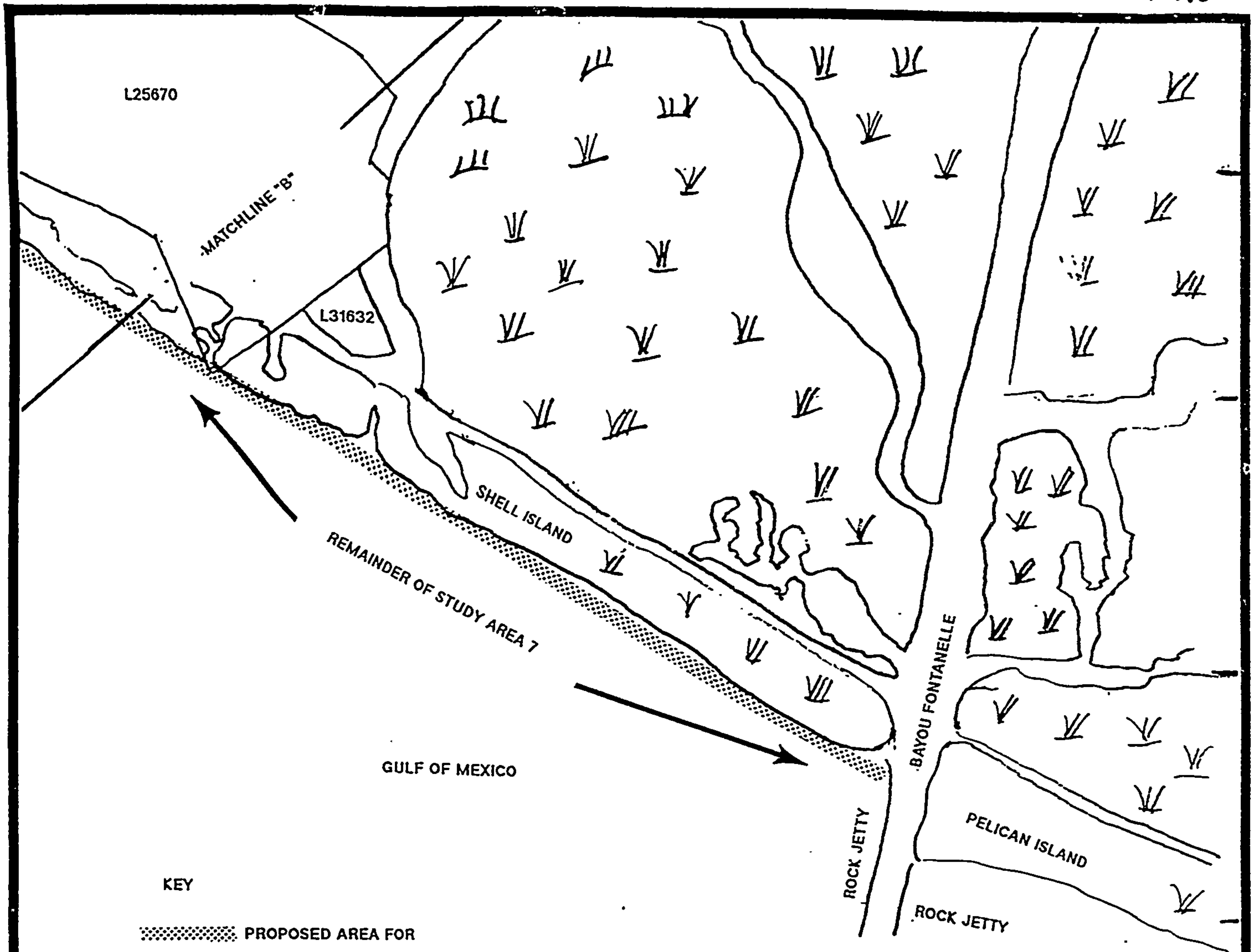
KAV



Final Plats
P920100
1 June 1992
KAU



Final Plate
P920100
1 June 1992
KAV



KEY

PROPOSED AREA FOR
BEACH CONES DEPLOYMENT

FROM 7.5' TOPO "BASTIAN BAY,LA" (1973) SCALE AS SHOWN
& TOPO "BURAS,LA" (1973) SCALE AS SHOWN

SHEET 3 OF 4

APPLICANT: DR. VICTOR LAW,TULANE UNIVERSITY

AGENT: E.P.L.,INC. METAIRIE,LA

38'00" 37'30" 37'00" 36'30" 36'00" 89°35'15"

Final Dist
P920100
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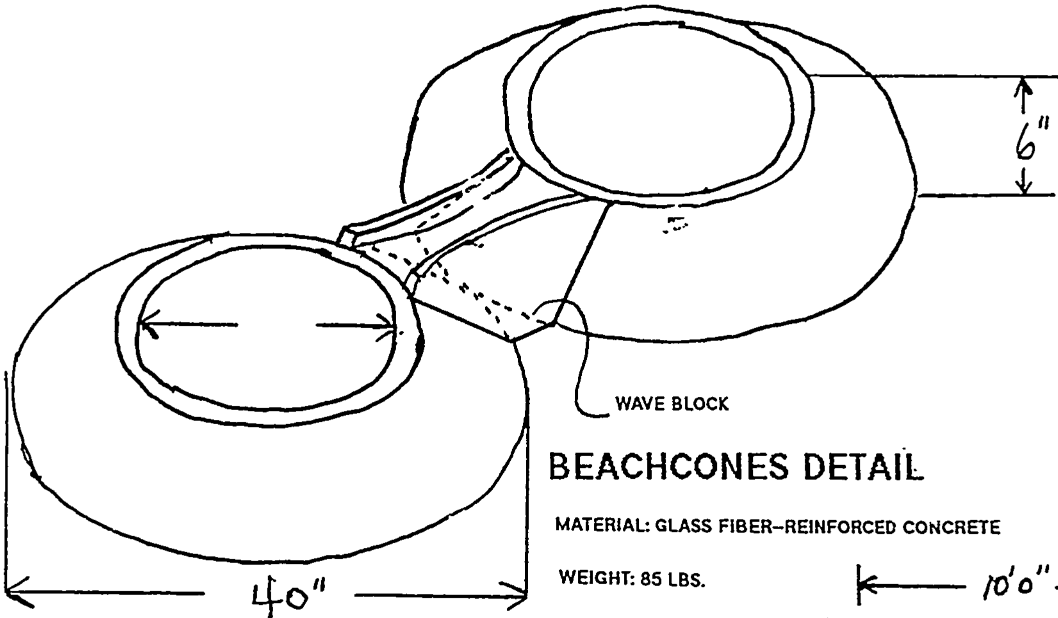
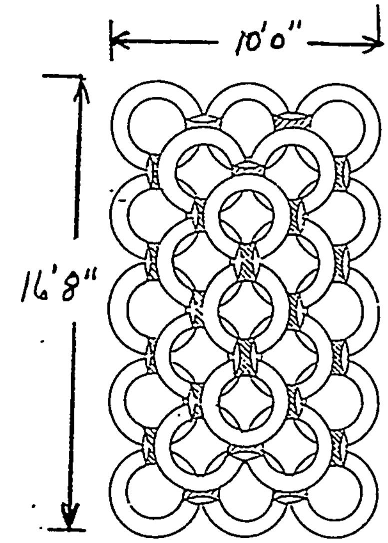


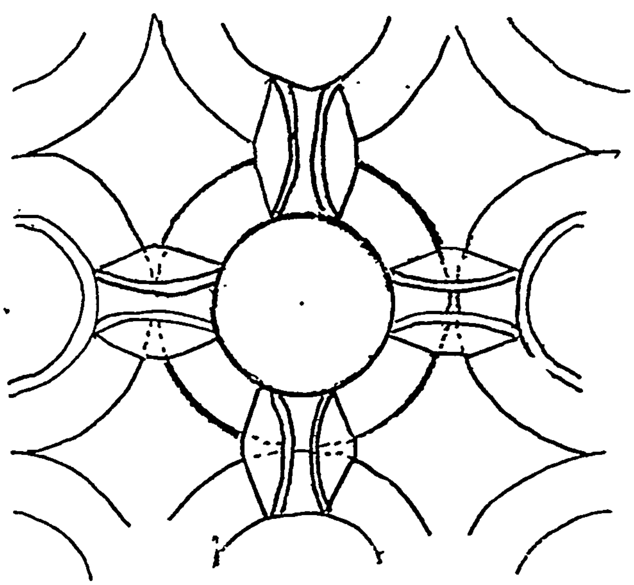
BEACHCONES DETAIL

MATERIAL: GLASS FIBER-REINFORCED CONCRETE

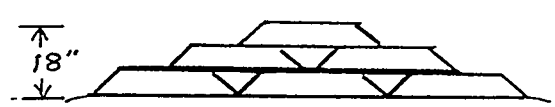
WEIGHT: 85 LBS.



PLAN VIEW OF 3-2-1 PYRAMIDAL INSTALLATION

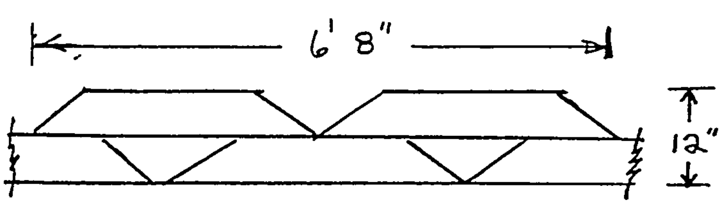


TYP. BEACHCONES ARRAY (PLAN)



ELEVATION OF 3-2-1 ARRAY

10'0"



TYP BEACHCONES 2-LEVEL ARRAY (ELEV.)

SHEET 4 OF 4

APPLICANT: DR. VICTOR LAW, TULANE UNIVERSITY

AGENT: E.P.L. INC. METAIRIE, LA

Final Plats
P920100
1 June 1992
KAV

NOTE 1. "Beach Cone" erosion control modules will be evaluated in 7 study areas. Within each study area one or more arrays of the beach cones will be installed to study the effect of differing orientations and/or geometric patterns.

NOTE 2. Spacing of beach cone arrays within study areas 1 though 6 will be no less than about 100 feet apart.

NOTE 3. Spacing of cones along the Gulf shore of Shell Island remnants (study area 7) will be no less than about 1000 feet apart.

NOTE 4. Effectiveness of the beach cones will be monitored frequently; during the two-year study. Applications deemed to be exacerbating shoreline loss will be removed properly and promptly.

NOTE 5. White, 2" diameter PVC pipes fitted with reflective tape will be used to mark the installations of beach cones. Each array's locations will also be protected with an 11" x 17" reflective sign identifying the array's location and warning boaters of the installation.

NOTE 6. Precise locations for deployment of beach cones within each of the seven study areas will be determined based on detailed field surveys including soil borings and identification of water bottom conditions.

NOTE 7. Please note on sheet 2 of 4 typical plan view of beach cone deployment relative to distance from shoreline and relationship to MHW and MLW levels.

NOTE 8. The approximate length and width of each study area is as follows:

Site 1: 1,500 ft. x 15 ft.
Site 2: 2,500 ft. x 15 ft.
Site 3: 2,500 ft. x 15 ft.
Site 4: 500 ft. x 15 ft.
Site 5: 600 ft. x 15 ft.
Site 6: 5,000 ft. x 15 ft.
Site 7: 27,000 ft. x 15 ft.